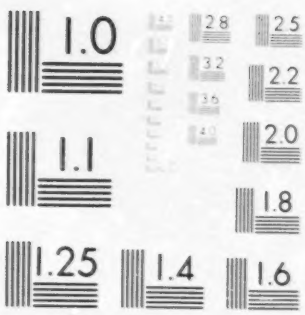


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS

DOCUMENT RESUME

ED 127 159 SE 021 161

AUTHOR	Sulkin, Naomi A.
TITLE	Projections of Degrees and Enrollment in Science and Engineering Fields to 1985.
INSTITUTION	National Science Foundation, Washington, D.C. Div. of Science Resources Studies.
REPORT NO	NSF-76-301
PUB DATE	Dec 75
NOTE	45p.; Cotains numerous pages of small print
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Stock Number 038-000-00268-6, $1.15)
EDRS PRICE	MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS	*Engineering Education; Higher Education; *Manpower Development; *Manpower Needs; *Science Education; *Scientific Manpower; Social Factors; Trend Analysis
IDENTIFIERS	*National Science Foundation

ABSTRACT

This report presents projections of the supply of scientists and engineers that are attributable to the higher education system of the United States, with emphasis on doctorate production. The forecasts given are said to represent numerical results that have been derived from specific models of the science and engineering manpower system. As such they are subject to the limitations of the models, and to the uncertainties inherent in the assumptions used. The two alternative sets of assumptions which underlie the projections presented here are explicitly outlined in the report, and sensitivity analyses are presented for possible further adjustment of the numerical results. A summary of the major trend relationships in Science/Engineering Education, past and projected, is given. Appendices include an overview of a projection model with a detailed description of its application at each stage of the higher education process covered by the report. Statistical tables and an extensive bibliography are included. (Author/EB)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

PROJECTIONS of degrees and employment in science and engineering fields to 1985

National Science Foundation
NSF 76-301

ED127159

PROJECTIONS of degrees and enrollment in science and engineering fields to 1985

National Science Foundation
NSF 76-301

FOREWORD

The United States, as a technologically advanced industrial Nation, is properly concerned with its supply of scientists and engineers. In the early sixties, the threat of impending shortages in these professions fostered Federal action to augment the supply of manpower highly trained in these fields. Today, it is the potential oversupply of such individuals, especially of those with doctorates, that causes apprehension. The dynamics of the system that makes scientists and engineers available for the numerous technical challenges facing the Nation are very complex. An approach to the analysis of the interrelationships in the system was presented in another Foundation publication, released in early 1975, *Projections of Science and Engineering Doctorate Supply and Utilization, 1980 and 1985* (NSF 75-301).

This report deals in detail with the projected additions to the supply of scientists and engineers that are attributable to the higher education system of the United States, with emphasis on doctorate production. Since methodologies are still very much in a state of development, it is not too surprising that the supply projections in the present report differ somewhat from those shown in the above-mentioned earlier NSF publication, though this change does not alter the general conclusions of the prior report. These differences indicate clearly that current projections should be regarded only as indicators of broad trends, and no false sense of precision should be attributed to any specific numerical values. It is important that users of this and similar current projections recognize that these forecasts represent numerical results that have been derived from specific models of the science and engineering manpower system. As such they are subject to the limitations of the models, and to the uncertainties inherent in the assumptions used.

The two alternative sets of assumptions which underlie the projections presented here are explicitly outlined in the report, and sensitivity analyses are presented for possible further adjustment of the numerical results. An assessment of the more likely set of assumptions has been made and these have been integrated into what has been called the Probable Model.

It is hoped that this study will provide further insight into the dynamics of the flow of students through the system of higher education. Undoubtedly, the methodology described can be further improved; any constructive, critical comments will be greatly appreciated.

Charles E. Falk
Director, Division of Science
Resources Studies

December 1975

acknowledgments

The model methodology on which the projections of this study are based was conceived by Justin C. Lewis, former Director of the Science Education Studies Group of the Division of Science Resources Studies of the National Science Foundation, and developed by Mr. Lewis and Naomi A. Sulkin, the author of the present report. Significant contributions to the model methodology and to the content of the report were made by Charles E. Falk, Director of the Division of Science Resources Studies, and Charles H. Dickens, present Director of the Science Education Studies Group, under whose general direction the report was prepared. J. Hamilton Andrews, Special Assistant to the Director of the Division of Science Resources Studies, also worked on the development of the methodology of the model. Indispensable statistical aide services were provided by Clifton Jackson, Gayle Barker, Janet A. Schneider, and Lola Edwards Seidl.

The National Science Foundation wishes to acknowledge the assistance of the following persons, in and outside the Foundation, who reviewed an interim report on the projection model and made valued suggestions: Robert Abel of the National Science Foundation (NSF); Robert W. Cain, formerly of NSF; Morris Cobern, NSF; Salvatore Corrallo of the U.S. Office of Education; Michael C. Crowley of the Federal Energy Administration; John K. Folger of the Education Commission of the States; Martin M. Frankel of the National Center for Education Statistics (NCES) (Department of Health, Education, & Welfare); Dorothy Gilford of the National Academy of Sciences-National Research Council (NAS-NRC); Gus W. Haggstrom of the RAND Corporation; Lindsey R. Harmon, NAS-NRC; Felix H. I. Lindsay, NSF; Thomas J. Mills, formerly of NSF; Neal Rosenthal of the Bureau of Labor Statistics; Kenneth Simon of NCES; and Larry E. Suter of the Bureau of the Census.

CONTENTS

	Page
Introduction	vi
Summary of Methodology	vii
Caveats	vii
Chapter I. Summary of Findings	1
Chapter II. Focus of Projections and Summary of Assumptions, Rationale, and Methods	5
Chapter III. Trends and Projections	9
Trends in S/E Enrollment and Degrees	9
Trend and Projection Relationships	12
Chapter IV. Summary of Major Trend Relationships in S/E Higher Education, Past and Projected	13
Appendixes:	
A. Technical Notes	16
Components of Fields of Science	16
Overview of Projection Model	16
Methodology in Detail	16
B. Statistical Tables	25
C. Bibliography	33

INTRODUCTION

This study is concerned with additions to the supply of scientists and engineers over the next decade attributable to the higher education system of the United States. The projections presented are based upon a number of explicit and implicit assumptions about the future. From the many possible scenarios, two were developed. A summary of the factors and assumptions used and their effect on the sensitivity of the projections are presented immediately below and in chapter II. The two projections models are called "Probable" and "Static." The Probable Model is thought to reflect the more likely course of future events as now perceived. The Static Model, by way of comparison, illustrates the effect of a balanced extension of both long-range past trends and current trends.

The two sets of projections, taken together, represent the range in which the selected series of higher education data are likely to fall in the next decade. Both sets of projections are based on the major trends observable in higher education in the period ending June 1972, the latest year for which data from the National Center for Education Statistics (Department of Health, Education, and Welfare) were available at the time the projections were made.

The Static Model assumes science and engineering (S/E) undergraduate and graduate student behavior will reflect *equally* the long-term upward trends in higher education which extended into the early years of the 10-year period ending June 1972 and the downward trends of the later years of the period. The Probable Model, on the other hand, assigns *double* weight to the trends of the later years of the period, which are presumed to reflect changes in students' attitudes toward S/E careers, in reaction to general economic conditions (including reversals in the labor market for scientists and engineers) and to some nonpecuniary factors.

The Probable Model thus assumes that the lower levels of demand of recent years for S/E manpower will continue, with corollary dampening effects on S/E degrees and enrollment.[1] Since the recent attitudes of students may be regarded to some extent as an over-reaction to the S/E manpower demand situation, the Probable Model, as has been indicated, gives weight also to the long-term upward trends in S/E higher education.

[1] Other analyses of the direction of trends in S/E manpower supply and utilization tend generally to agree with the expectation of an imbalance in the direction of oversupply or underutilization in the projected period. See U.S. Department of Labor, Bureau of Labor Statistics, *Ph.D. Manpower: Employment, Demand, and Supply, 1972-85*, Bulletin 1860, 1975 and National Science Foundation, *Projections of Science and Engineering Doctorate Supply and Utilization, 1980 and 1985* (NSF 75-301), 1975. (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office); see also Cartter, Allan M., "Scientific Manpower for 1970-1985," *Science* 172 (April 9, 1971).

Summary of Methodology

The projection methodology of this study utilizes a demographic model tracing the flow of students through five stages of the higher education process—from college entrance to the acquisition of the doctorate—and employing time-series analyses, trend projections, and extrapolative forecasting techniques to develop data for the years through 1985. Each of the two sets of projections presented adheres to the trend-weighting system described above at all stages of the projection model, and, at each stage after the first, reflects the cumulative effect of the application of the system at the earlier stage(s) of the model.

The methodology is one that can lend itself readily to the development of projections based on varying sets of assumptions. The projection model utilized in the method is sensitive, in terms of its outputs, to variations in assumptions and in the trend-weighting systems used to implement the effects of these assumptions.

The projections are based on only two of several possible sets of assumptions. While keeping in mind the factor of arbitrariness necessarily involved in the choice of assumptions to be developed via the method, it is nevertheless useful to examine what the method will produce within the parameters of these assumptions. The products of the projection model illustrated here thus give an indication of the magnitude of possible future degrees and enrollment for advanced degrees in S/E fields and of the ranges in which they may fall.

Caveats

The nature of the projection methodology and the assumptions and factors used make it imperative to emphasize a number of caveats which should be kept in mind when examining the results of this analysis.

Projections are not predictions. Projections are derived from statistical models based on trends and an awareness of current happenings. Thus, they produce a range of possible future situations based on definitive assumptions of specific situations and no significant breaks in trends.

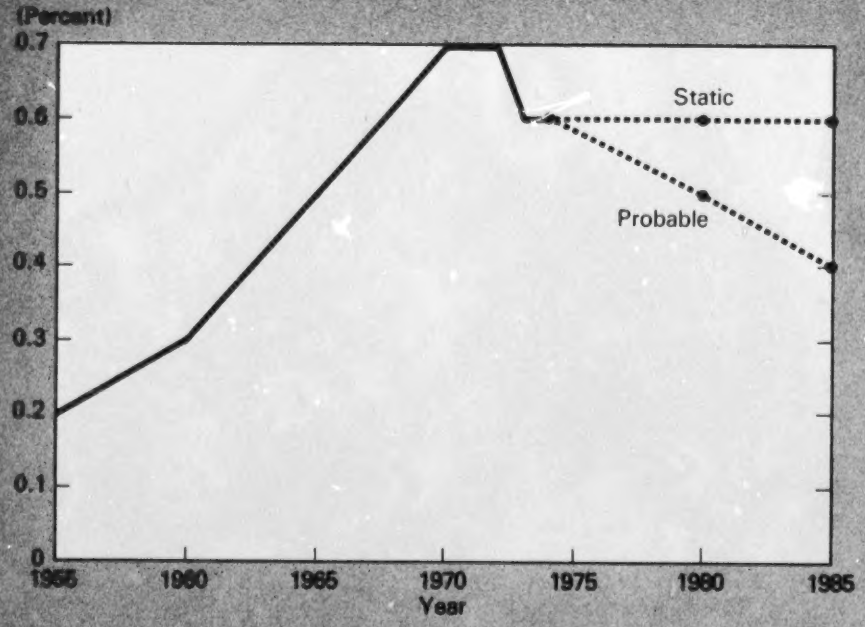
No false sense of precision should be attributed to numerical values in view of the limitations of the data and methodologies, the complexities of the system, and the predictability of future events. The last factor requires special emphasis since long-term projections, by their very nature, cannot take into consideration factors impossible to anticipate at the time the projections are made. With an appropriate understanding of these uncertainties, projective studies of this kind do produce broad indications of the range of the likely supply of S/E personnel.

Each major area of science includes a number of specific fields or disciplines (e.g., physics, biology, electrical engineering, economics, statistics) that may differ from each other in their supply situation. Thus, it must not be assumed that the aggregate situation for a broad area of science (e.g., the physical sciences) is necessarily applicable to individual disciplines within the area.

Chapter 1. SUMMARY OF FINDINGS

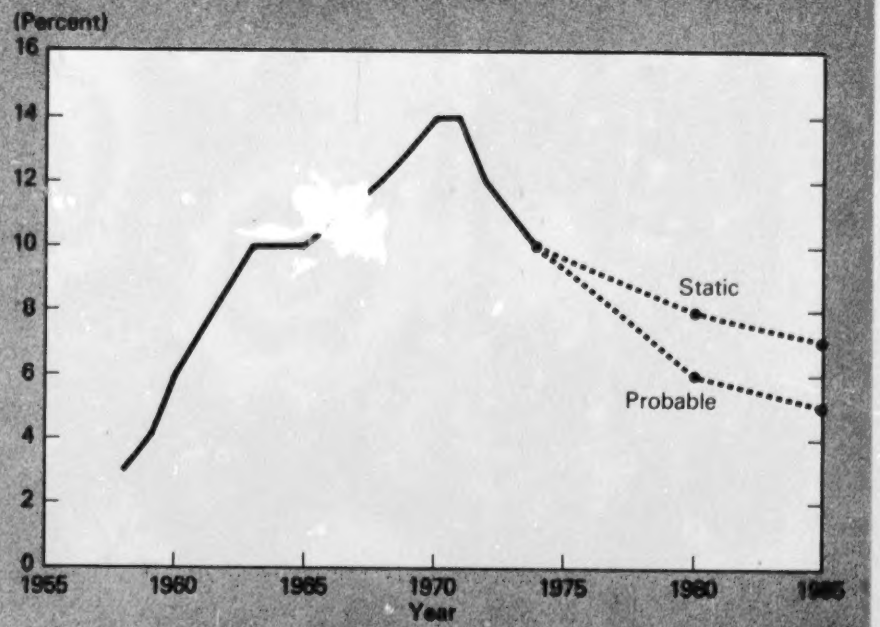
- Science and engineering (S/E) doctorate production for the period 1975 through 1985 is projected to fall within the range of 195,000 to 235,000, with greater likelihood for the lower number. The output of S/E doctorates in both models for the projected period is expected to exceed that of the preceding period of comparable length. This situation results in large measure from the greater magnitude of the traditional doctorate-age population in the projected period as compared to the preceding period. Increases in S/E doctorate production, however, because of the effects of recent downward trends in the rates of involvement in S/E higher education, are not expected to keep pace with population increases. S/E doctorates for 1975 to 1985 are projected by the Probable Model to exceed those of the preceding period of comparable length by only about 20 percent, whereas 30-year-olds will outnumber those in the preceding period by 46 percent.
- Annual production of S/E doctorates in the Probable Model shows a marked tendency to decline in relation to other factors. For example, the number of S/E doctorates as a percent of the 30-year-old population is expected to return by 1985 to the level of the early sixties—0.4 percent (chart 1). Similarly, S/E doctorates as a percent of the number of S/E baccalaureates eight years earlier are expected by 1985 to fall below the 1960 level of 6 percent (chart 2). The Static Model projections yield larger estimates for these relationships in 1985, but even the Static estimates are below the high levels observed in 1970 and 1971, when S/E doctorates were 0.7 percent of the 30-year-old population and 14 percent of the number of S/E baccalaureates eight years earlier.

Chart 1. Annual science/engineering doctorate production as a *percent* of the 30-year-old population



Note: Dotted lines from 1974 to 1980 and 1985 serve only to connect the actual data with the projections for 1980 and 1985 and should not be interpreted as representing projected values for the intervening years.

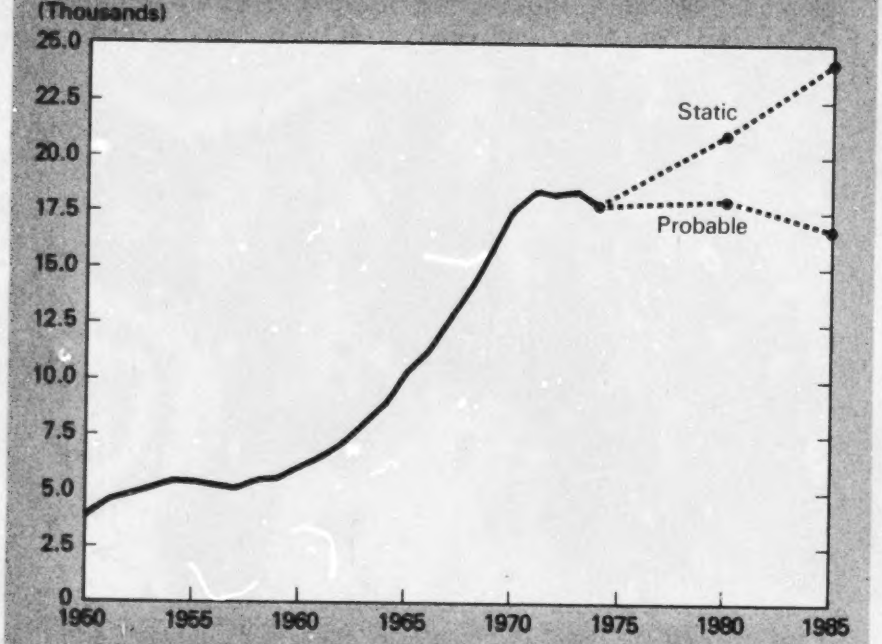
Chart 2. Science/engineering doctorates as a *percent* of science/engineering baccalaureates 8 years earlier



SOURCES: National Center for Education Statistics; National Academy of Sciences — National Research Council; National Science Foundation (tables B-1 and B-2); and U.S. Bureau of the Census.

- The effect of the differing assumptions of the Probable and Static methods is evident when the two models are compared in terms of the production of S/E doctorates (chart 3). The Probable Model, which gives double weight to the overall downward trends of the later years of the period on which the projections are based, yields S/E doctorate projections that remain essentially constant in magnitude until 1980; thereafter the numbers of doctorates decline somewhat, reaching in 1985 a level a little below that of 1970. The magnitude of the projections of the Static Model, on the other hand, increases continuously over the projected period. The relatively stable level of the output of the Probable Model results largely from the increase in the population of the age of doctorate-level education in the projected period.

Chart 3. Science/engineering doctorate production: 1950-74 and projections for 1980 and 1985

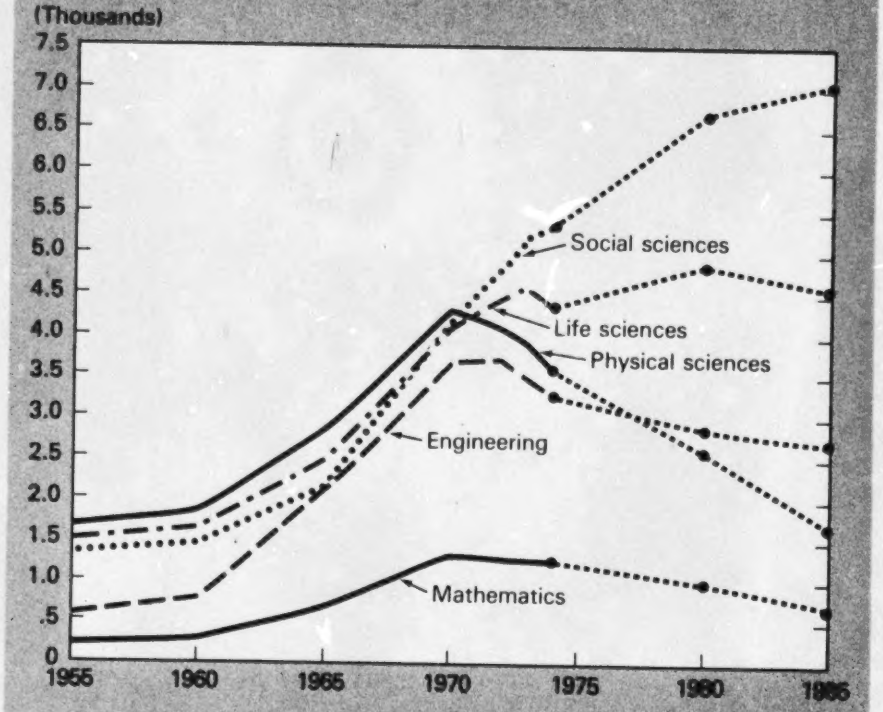


Note: Dotted lines from 1974 to 1980 and 1985 serve only to connect the actual data with the projections and should not be interpreted as representing projected values for the intervening years.

SOURCE: National Center for Education Statistics (HEW), National Academy of Sciences — National Research Council, and National Science Foundation (table B-3).

- The social sciences and the life sciences are the only fields in the Probable projections in which greater numbers of doctorates are expected to be produced in 1980 and 1985 than in 1974. The physical sciences are expected to experience the greatest percentage decline (Probable projections) in numbers of doctorates between 1974 and 1985. Similarly, the social sciences are expected to show the greatest growth between 1974 and 1985, and the physical sciences the greatest decline, in the proportion the field will constitute of all S/E doctorates (Probable projection) (chart 4).

Chart 4. Doctorates in the five major science/engineering fields: selected years 1955-74 and Probable projections for 1980 and 1985

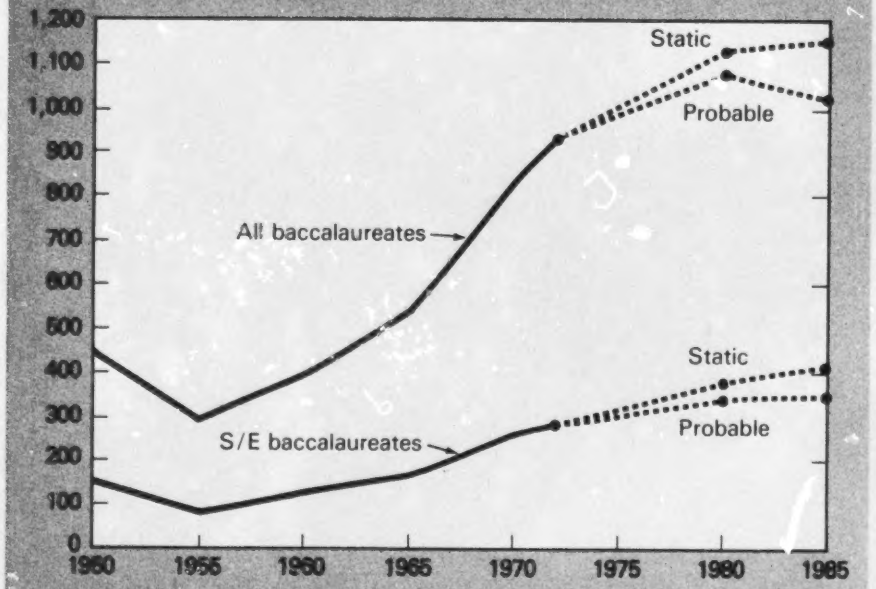


Note: Dotted lines from 1974 to 1980 and 1985 serve only to connect the actual data with the projections and should not be interpreted as representing projected values for the intervening years.

SOURCE: National Center for Education Statistics (HEW), National Academy of Sciences — National Research Council, National Science Foundation (table B-3).

- S/E baccalaureate production in the 1973-85 period is projected to exceed that of the preceding period of comparable length as the result of increases in both the size of the population of the traditional baccalaureate age-group and the proportion of that population which is expected to achieve the bachelor's degree. For the Probable projection the increase will be about 75 percent (charts 5 and 6).

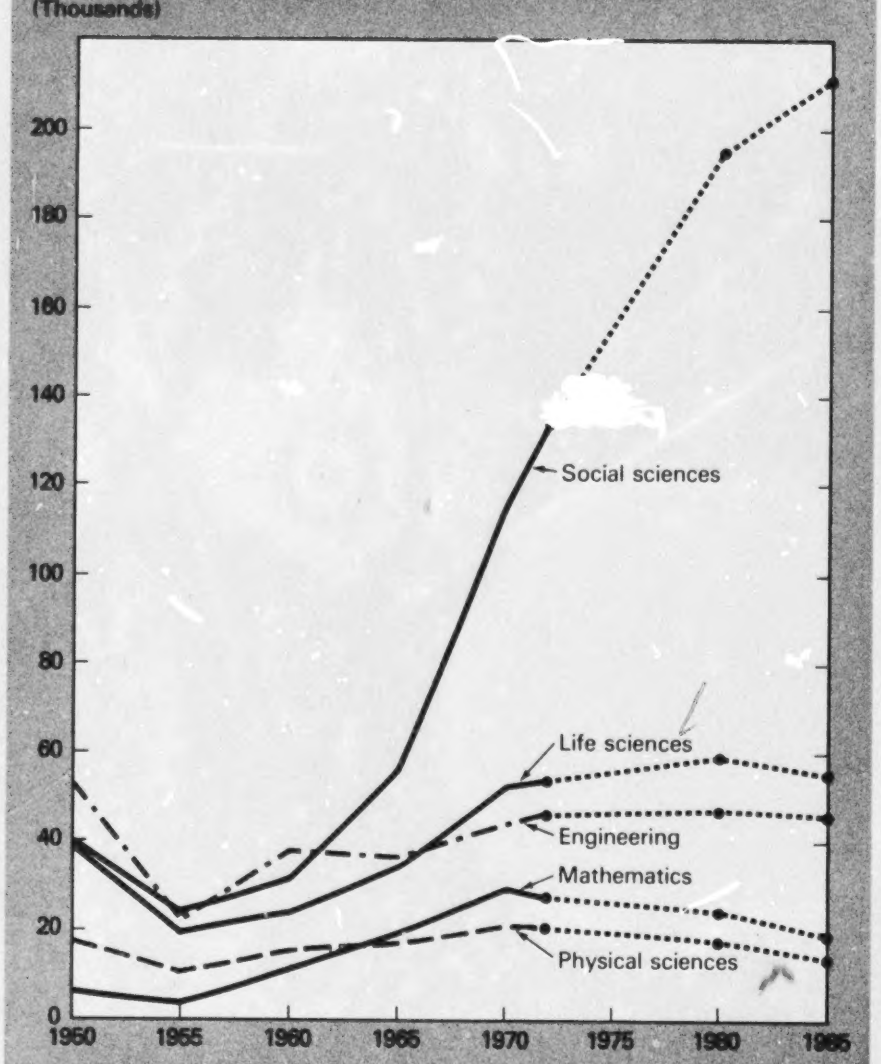
Chart 5. Total and science/engineering baccalaureate production: 1960-72 and projections for 1980 and 1985



Note: Dotted lines from 1972 to 1980 and 1985 serve only to connect the actual data with the projections and should not be interpreted as representing projected values for the intervening years.

SOURCE: National Center for Education Statistics (HEW); National Science Foundation (table B-4).

Chart 6. Baccalaureates in the five major science/engineering fields: 1960-72 and Probable projections for 1980 and 1985

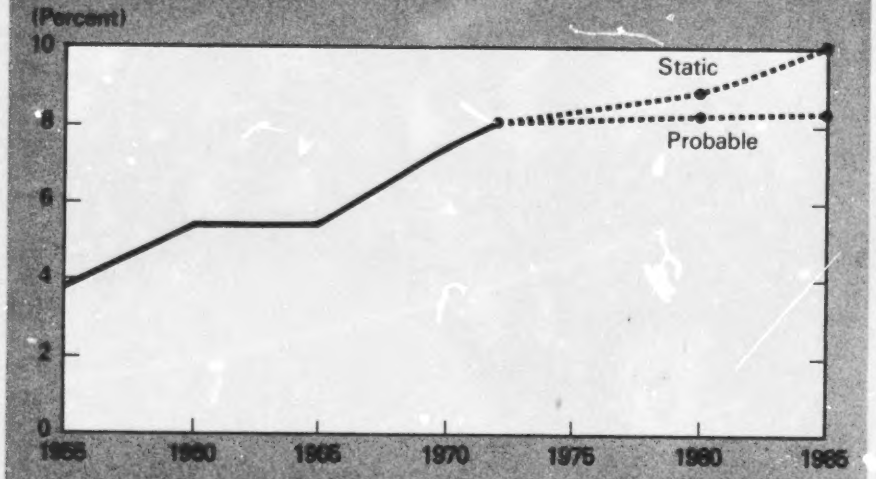


Note: Dotted lines from 1972 to 1980 and 1985 serve only to connect the actual data with the projections and should not be interpreted as representing projected values for the intervening years.

SOURCES: National Center for Education Statistics (HEW); National Science Foundation (table B-4).

- S/E baccalaureates in relation to the 22-year-old population increased from 4 percent in 1955 to 8 percent in 1972 and are projected to continue to increase slightly over the projected period (chart 7).

Chart 7. Science/engineering baccalaureates as a percent of 22-year-old population

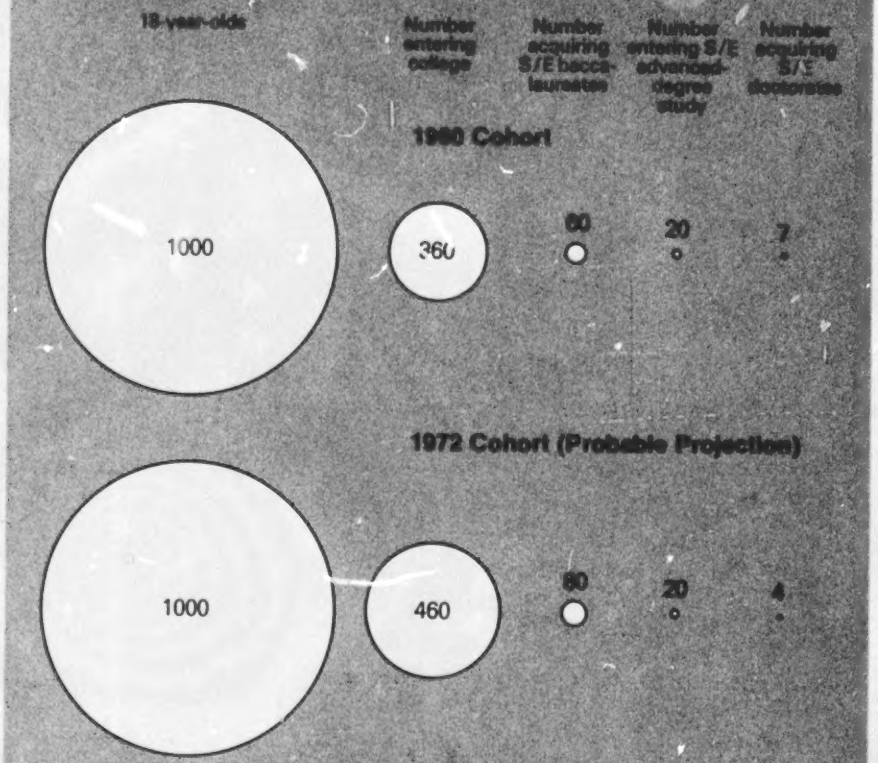


Note: Dotted lines from 1972 to 1980 and 1985 serve only to connect the actual data with the projections for 1980 and 1985 and should not be interpreted as representing projected values for the intervening years.

SOURCE: National Center for Education Statistics (HEW) and National Science Foundation (table B-1).

- The rate of S/E doctorate attainment projected for the 18-year-olds of 1972 is substantially lower than that of the 18-year-olds of 1960, in spite of the expectation that the 1972 cohort will enter college and attain the baccalaureate in S/E fields at a higher rate than the cohort of 1960 (chart 8). The lower rate of attainment of the S/E doctorate projected for the 1972 cohort is a reflection of the expectation of steadily decreasing rates of attainment of the doctorate among entrants into advanced-degree study in S/E fields.

Chart 8. Science/engineering baccalaureate and doctorate production among population cohorts aged 18 in 1960 and in 1972



SOURCES: National Center for Education Statistics (HEW) and National Science Foundation.

Chapter II. FOCUS OF PROJECTIONS AND SUMMARY OF ASSUMPTIONS, RATIONALE, AND METHODS

Focus of Projections

This report examines the extent of participation in selected phases of the higher education process in the United States over the past two decades and projects the extent of such involvement in the next decade. Beyond the baccalaureate level, this study is concerned with higher education in S/E fields only.[2]

Long-term trends in educational attainment in the United States have moved in a steady upward direction in the last several decades. Among the population aged 25 and over, for example, the proportion who are high school graduates has been increasing, as has the proportion with a year or more of college education. Similarly, in each decade a greater proportion of the college-age population has participated in higher education. In the fifties and early sixties, especially, there was relatively rapid growth in the numbers of Americans participating in the higher education process and in the rate of participation in that process by those of traditional college and graduate-student age.

In recent years, however, a reversal of this growth trend occurred in the form of lower participation rates in higher education and also of decreases in the proportion of student population groups continuing from one stage of higher education to the next. Some reduction in actual numbers of students engaged in particular phases of higher education or in specific subject-matter fields or categories of education also took place. The S/E component of higher education in particular showed decreases in the rates of participation and continuation from one stage of the higher education process to the next and, in some fields, decreases in the actual numbers of students involved.[3]

For the purpose of projecting degrees and enrollment a methodology was developed which would take into account the influence of both the long-term upward trends of the fifties and early sixties and the reversals of more recent years. In the model methodology, participation in the higher education process was traced and described from the point of view of the observation over a period of time of the flow and progress of specified population cohorts into college; of college entrants to the baccalaureate; of baccalaureates to entrance into advanced-degree study in S/E fields; of entrants into advanced-degree study in S/E fields to doctorates in those fields. Data on *total* enrollment for advanced degrees in S/E fields—i.e., enrollees at all stages of advanced-degree study—were also obtained on the basis of the numbers of entrants into advanced-degree study calculated for the series of years involved.

From salient trends over the observed period of the past in the movement of individuals at each of these major stages of higher education, projections were made of the percent and number of students at each stage who would, through 1985, finish the stage, and, where applicable, of the percent and number of those finishing who would go on to the next stage. Two series of projections, called *Probable* and *Static* were ultimately developed for selected categories of enrollment and degrees on the basis of a set of assumptions and weighting methods described briefly in the initial introduction to this report and to be described in more detail in the next section of this chapter.

[2] See appendix A for a list of the components of S/E fields in accordance with the National Science Foundation taxonomy.

[3] The trend relationship tables in chapter IV illustrate the nature of the declines which have occurred in S/E higher education.

Summary of Assumptions, Rationale, and Methods

Various explicit and implicit assumptions underlie the methodology of the two projection models for S/E bachelor's and doctor's degrees and enrollment for advanced degrees developed for this study. Essentially, these assumptions reflect expectations of some continuity with the past, with provision in each of the two models for differential weighting of the two chief trend lines of the recent past with respect to rates of participation in S/E higher education. The basic differences in the assumptions and the methodology[4] of the two projection models, Static and Probable, are the following: the Static Model assumes that the upward trends in S/E higher education which occurred in the *early* years of the most recent 10 years for which data are available will have an influence equal to that of the downward trends of the *later* years of the period on participation and continuation in S/E higher education over the projected period. The Probable Model differs by assuming that the downward trends of the *later* years of the period, expressing as they do a reaction to labor market conditions and to various nonpecuniary factors, will have twice as much influence on rates of involvement in S/E fields in higher education.

Implicit assumptions of continuity with the past are also made with respect to the general environment for the projections, i.e., the socioeconomic climate of the country and the nature of the higher education system. The assumption is made that the broad socioeconomic and higher-education patterns of the past will continue, with no major economic upheavals comparable to a great depression, and no radical departures from patterns of financing of higher education or from the attitudes and values of the past with respect to higher education.

The accompanying table presents a comparison of the assumptions and rationales of the two projection models, along with an illustration of the degree of sensitivity involved in their relative outputs. Other assumptions of the model methodology are also listed in the table, with their rationales and, in some cases, illustrations of their sensitivity.

[4] A detailed description of the methodology appears in appendix A.

Assumptions, Rationale, and Sensitivity of Projection Models

Item	Assumptions/Method	Rationale	Sensitivity
1. Static Model	Upward trends of early years of last decade and downward trends of later years will have equal effect on participation and continuation rates in S/E higher education over the projected period. Both trend lines given equal weight.	Upward trends of early years of last decade are a continuation of strong long-term trends which will affect S/E higher education as much as the downward trends of recent years; latter may be an over-reaction of brief duration to S/E labor market conditions and other factors.	Decreases in participation/continuation rates projected via a trend-weighting system of this type do not occur in a linear fashion as a function of the magnitude of the weight placed on trends of the most recent years. Rates yielded by successively greater weighting of recent trends (in combination with earlier trends) approach asymptotically rates projected solely on the basis of recent trends. The use of the double weight for recent trends in the Probable Model comes close to producing the maximum reduction in participation/continuation rates at each stage of the model where it is used.
vs.			
Probable Model	Downward trends of more recent years of last decade will have twice as much effect as upward trends of earlier years on participation in S/E higher education over next decade. Trends of more recent years given double weight in combination with those of earlier years.	The break in long-term upward trends represented by the recent downturns was relatively sharp and abrupt; the trends have continued down and there is no firm evidence of leveling off. The downward trends, representing a response to labor market conditions of the recent past which are expected to continue, will exert a more powerful influence on involvement in S/E higher education over the next decade than the upward trend of the earlier years.	The ultimate effect of the double-weighting of recent trends throughout the model process is the projection of 31% fewer S/E doctorates for the year 1984-85 in the Probable Model than in the Static. Over the entire projected period 1975-85 the Probable Model projects 17% fewer S/E doctorates than the Static.
2. Proportion of bachelor's degrees awarded in the physical sciences	Decrease in proportion of baccalaureates in physical sciences will not continue at rates of last 10 observed years, but will proceed on a reduced basis; the percent of degrees to be awarded in the field in 1985 is assumed to fall at a point halfway between the last observed percentage point and the point projected for 1985 by the full force of a straight-line least-squares regression. (Both models)	A continuation of decreases at recent rates would result in unrealistically small numbers of degrees in the field in the 1980's. (See detailed Methodology, disaggregation of total baccalaureates.)	Use of the declining rate of the full force of the regression would have resulted in 18% fewer physical science doctorates in 1984-85 and 1.8% fewer total S/E doctorates in the same year (Probable projection).
3. Rate of attainment of baccalaureate degrees among male college entrants	Rate during projected period will remain at *constant level of last five college-entrance cohorts* for whom baccalaureate-attainment data were available. Slightly upward trend-line of attainment rates over period of last 10 years for which data available is not extrapolated. (Both models)	Changing characteristics—such as increasing proportions entering 2-year rather than 4-year institutions—among more recent groups of college entrants do not warrant assumption that completion rate will rise. (See appendix A, Matrix II.)	Use of a rising completion rate based on extrapolated trend-line would produce only 0.6% more male baccalaureates in toto in all fields over the projected period 1973-81. A corresponding increase in the number of S/E baccalaureates over this period would have such a negligible effect on the number of S/E doctorates in 1984-85 that sensitivity was not calculated (Probable projection).

Assumptions, Rationale, and Sensitivity of Projection Models—Cont.

Item	Assumptions/Method	Rationale	Sensitivity
4. Rates of attainment of doctorate among women in the life sciences and the social sciences	Rates of attainment of doctorate among women entrants into advanced-degree study in these fields will by 1985 equal but not exceed those for men. (Both models)	If projected on basis of most recent 10 years, rates would exceed those for men by 1985. These rates seem unrealistic for the following reasons: (1) rates of women have been falling for those cohorts who entered advanced-degree study after 1961; (2) since these two fields are the largest for women in advanced-degree study, it seems reasonable to assume that as women participate in greater numbers and proportions in study at this level, their behavior will tend to approach that of the norm or the total population involved in the field. (See treatment of subject in appendix A, Matrix V.)	Use of rates of attainment for women based on projections of trends of women's rates of most recent 10 years would result in 3.7% more life sciences doctorates in 1984-85 and 2.9% more social science doctorates in that year (Probable projection, total doctorates:)
5. Rate of attainment of baccalaureate among women college entrants	Rate will gradually rise to equal but not exceed that of men by 1985. (Both models.)	Rate rose in early years of last 10, but slowed down and leveled off in later years. If projected on basis of last 10 years, rate would exceed that for men by 1985. Taking women's rate up to that of men by 1985 raises the rate steadily from the last observed rate to one several points higher by 1985. Though it seems reasonable to do this—see (2) above under Rationale for Item 4 in this table—it would seem unrealistic to raise women's rate still further in the light of changing characteristics and composition of most recent groups of women entrants. See *Rationale* for *Item No. 3* in this table.	Use of rates of attainment for women based on projections of trend lines of women's rates would result in 1.4% more women baccalaureates over the entire projected period 1973-81 and 0.3% more S/E doctorates in 1984-85. (Probable projections, total doctorates.)
6. "Spread" or time-pattern of attainment or completion of indicated stages of higher education process (Same time-patterns used in both models.)	The "spread" or time pattern of: a. Entrance into college of those from a population cohort who will ever enter remained stable over the observed period of two and one-half decades and is expected to continue as observed over the projected period. b. Completion of college of those members of college-entrance cohorts who will ever attain the baccalaureate or a first-professional degree remained stable over the observed period of two decades and is projected to continue as observed. c. Entrance into S/E advanced-degree study among S/E baccalaureates who will ever enter such study remained stable over the observed period of approximately a decade and a half and is expected to continue as observed over the projected period. d. Attainment of the doctorate among entrants into advanced-degree study who will ever attain the degree has reamined stable over the observed period and is projected to continue as observed.	Stability of time-patterns a. - d. over observed periods warrants continuation and extension of patterns into projected periods.	Tests of reasonable hypothetical variations in time-spread yielded results which varied only slightly from the output of the basic model. For example, the spread of entrance into advanced-degree study (item c) of men in the physical sciences was decreased 10% for those entering one year after the baccalaureate and increased 10% for those entering two years after; the result was 0.7% fewer male physical science doc- in 1984-85. (Probable projection.)

Chapter III. TRENDS AND PROJECTIONS

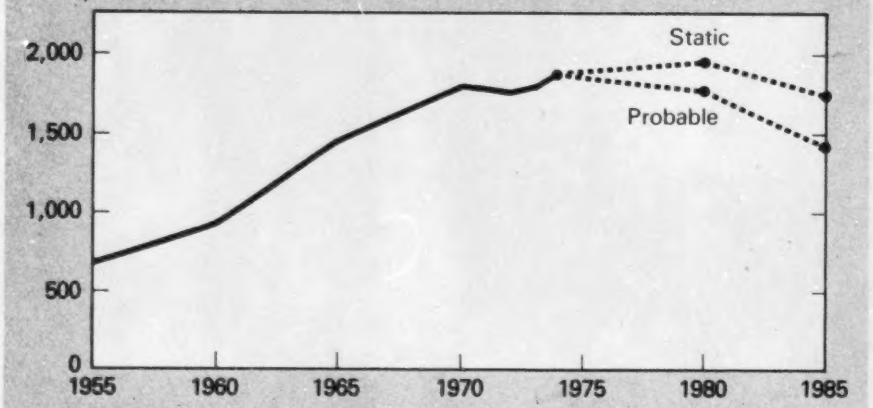
Note: All population components under discussion, in the higher education process and in the general population, have already been born; no data presented here go far enough into the future to involve birth projections.

Trends in S/E Enrollment and Degrees

COLLEGE ENTRANTS

As can be seen from chart 9, the number of college entrants (first-time degree-credit enrollees in programs or courses creditable to a bachelor's or higher degree) grew steadily over the period 1955-74 and in 1974 reached a magnitude over 2-3/4 times that of 1955. The slight declines observed in 1971 and 1972 were reversed in 1973 and 1974. Projections of numbers of college entrants for the years 1980 and 1985 are also presented on this chart.

Chart 9. Number of college entrants, fall 1955-74, and Probable and Static projections for fall 1980 and fall 1985



Notes: Dotted lines from 1974 to 1980 and 1985 serve only to connect the actual data with the projections and should not be interpreted as representing projected values for the intervening years.

SOURCES: National Center for Education Statistics (HEW), data on first-time degree-credit enrollees from annual Opening Fall Enrollment surveys; National Science Foundation (table B-5); U.S. Bureau of the Census (table B-10).

Over the projected period 1975-85, the number of college entrants will range from 19 million to 21 million, an increase of 5 percent to 17 percent over the numbers of entrants in the preceding period of comparable length. This increase is a reflection of the greater magnitude of the population of college-entrance age in the projected period as compared to the preceding period.

BACCALAUREATES

Bachelor's and first-professional degree production in all fields and bachelor's degree production in S/E fields as a whole grew continuously from 1959-60 through 1971-72 (the latest year for which the National Center for Education Statistics (NCES)[5] data are available), as can be seen from chart 5. Annual production of S/E baccalaureates doubled in the period from 1960 to 1972. In individual major fields, like the mathematical and physical sciences, however, decreases in numbers of baccalaureates occurred in the most recent years (chart 6). The strongest growth in S/E fields over the period took place in the social sciences among both men and women baccalaureates. (See table B-4.)

In relation to total baccalaureates and first-professional degrees in the last five years, S/E baccalaureates have fallen slightly from 32 percent in 1968-70 to 31 percent in 1971 and 30 percent in 1972. Among men baccalaureates, the S/E component dropped in the last five years from 40 percent in the 1968-70 period to 39 percent in 1971 and 37 percent in 1972. For women, the proportion of baccalaureates in the S/E fields rose gradually through the sixties and reached the 20-percent level in 1969, where it remained through 1972.

By 1980, S/E baccalaureates (both sexes) are likely to constitute from 32 percent to 33 percent of all baccalaureates and first-professional degrees; by 1985, from 34 percent to 35 percent (table B-4). This anticipated rise from the

[5] Prior to August 1, 1974 the organization now designated as the *National Center for Education Statistics* (NCES) of the Department of Health, Education, and Welfare was a part of the Office of Education (OE) and its publications were designated as OE publications. Since the data and publications issued by this organization are now designated as NCES material, this report will refer to the NCES as the source of all such material, regardless of its date of issue.

1972 level is attributable chiefly to continuing growth in the numbers of social science baccalaureates among both men and women. The physical sciences are expected to continue to decline in numbers and as a proportion of all S/E degrees.

By 1980 S/E baccalaureates among men are projected to constitute 38 percent of all baccalaureates and first-professional degrees; by 1985, S/E baccalaureates will have returned to the 1971 level of 39 percent of all baccalaureates and first-professional degrees (Probable projection). Among women, S/E baccalaureates will rise as a proportion of all baccalaureates and first-professional degrees to 24 percent by 1980 and 27 percent by 1985 (Probable projection).

ENROLLMENT FOR ADVANCED DEGREES IN S/E FIELDS

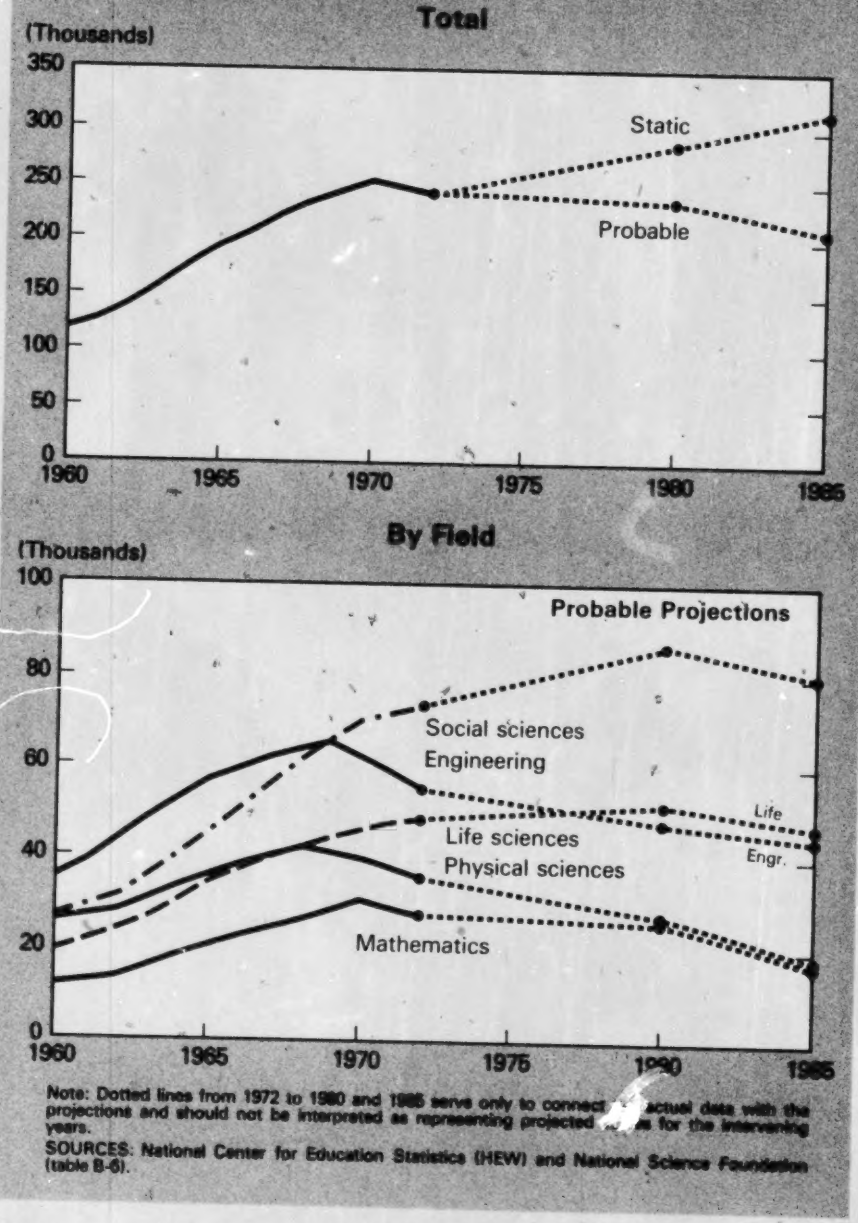
Enrollment for advanced degrees in S/E fields rose steadily during the sixties, from 120,000 enrollees in 1960 to twice that number in 1969. In 1970 these enrollments reached a peak in magnitude of approximately 250,000, but fell in 1971 and 1972 to approximately the 1969 level (chart 10).

In two S/E fields, the life sciences and the social sciences, enrollment continued to climb throughout the entire period 1960-72; in the social sciences in 1972 enrollment was 2-3/4 times that of 1960 (chart 10). In the remaining three fields—the physical sciences, engineering, and the mathematical sciences—there was variation in the year of peak enrollment, that year occurring in 1968 for the physical sciences, in 1969 for engineering, and in 1970 for the mathematical sciences. The greatest relative decrease from the year of peak enrollment to 1972—14 percent—appeared in engineering. Enrollment for advanced degrees data by sex are available only from 1966 on and can be seen in table B-6.

Total S/E advanced-degree enrollment is expected in the Probable projections to begin to decrease gradually in the mid-to-late seventies, reaching 210,000 in 1985, a level 13 percent below that of 1972. In the Static projection, these S/E enrollments increase throughout the period and reach 315,000 by 1985, a figure almost 30 percent higher than that of 1972. (See projections for 1980 and 1985 in table B-6.) This difference in the two projections is the result of the differences between the two methods in: (1) the numbers of S/E baccalaureates to be produced in the projected period; and (2) the rates of entrance into advanced-degree study projected for these baccalaureates over the period. (These differences are also reflected in the projections of numbers of first-time enrollees for an advanced degree (See table B-7).

Individual S/E fields may differ in either set of projections from the trends of S/E enrollment for advanced degrees as a whole. In the social

Chart 10. Science/engineering enrollment for advanced degrees: 1960-72 and 1980 and 1985 projections



Note: Dotted lines from 1972 to 1980 and 1985 serve only to connect the actual data with the projections and should not be interpreted as representing projected values for the intervening years.

SOURCES: National Center for Education Statistics (HEW) and National Science Foundation (table B-6).

sciences, for example, in the Probable projections, enrollment increases are continuous until after 1980, and even the figure projected for 1985 is greater than the 1972 enrollment in this field. The life sciences Probable projections follow a pattern highly similar to that of the social sciences, except that the enrollment figure for the year 1985 is slightly lower than the 1972 figure. In the remaining three S/E fields in the Probable projection there is continuously decreasing enrollment throughout the projected period. In the physical sciences this decline is more marked than in any other field, the 1985 Probable enrollment being only 53 percent of that of 1972.

In the Static projection the physical sciences is the only field which runs counter to the upward trend of S/E fields as a whole; the magnitude of its enrollment declines steadily over the projected period, to a level 75 percent of 1972 enrollment by 1985.

Caveat: The degree of uncertainty inherent in the projections of total enrollment for advanced degrees (i.e., the number of enrollees at all stages of advanced-degree study) is greater than that in the projections of bachelor's and doctor's degrees or first-time enrollment for advanced degrees, as will be pointed out in the detailed description of the methodology involved in enrollment for advanced-degree projections. (See appendix A, Enrollment for Advanced Degrees section.)

DOCTORATES IN S/E FIELDS

Annual doctorate production in S/E fields tripled between 1960 and 1971 and held in 1972 at approximately the 1971 level (table B-3). The physical sciences component of doctorates dropped from 30 percent in 1960 to 22 percent in 1972, whereas the engineering component grew from 13 percent to 20 percent in the same period. The other three S/E fields each constituted approximately the same proportion of total S/E doctorates at the beginning and at the end of the period.

In the 5-year period ending 1972, the fields experiencing the greatest proportionate growth numerically were the social sciences and the life sciences, where doctorate production in 1972 was 1-2/3 times that of 1967 for the social sciences and over 1-1/2 times that of 1967 for the life sciences. For women, the corresponding growth in these two fields over this period was somewhat higher than that for both sexes together; in the social sciences, for example, the number of women doctorates in 1972 was double that of 1967 (table B-3).

Among men, too, the greatest proportionate numerical growth occurred in the social sciences and the life sciences (table B-3). In the physical sciences growth was only 16 percent—strikingly lower than that in any other field. Engineering, the field second lowest in growth in 1972 as compared to 1967, had, nevertheless, at 41 percent, a considerably higher rate of increase than the physical sciences.

For the years 1972-73 and 1973-74 NSF has made estimates of S/E doctorates from the numbers reported for those years by the National Academy of Sciences-National Research Council (NAS-NRC), on the basis of past relationships between the NCES doctorate data series and that of the NAS-NRC in the major S/E fields. These estimates (table B-3) indicate that S/E doctorate production reached a high point in 1973 comparable to that of 1971, but then returned in 1974 to approximately the level of 1970.

In the period 1972-74 there was a continuation of some of the trends of the 1960-72 period. The physical sciences component of total S/E doctorates, for example, dropped further, to 20 percent of all S/E doctorates in 1974, while the social sciences, which constituted 24 percent of S/E doctorates in 1960 and 26 percent in 1972, rose in 1974 to 29 percent. The numbers of S/E doctorates by field in 1974 as compared to 1967 illustrate a continuation also of some of the trends of the 1967-72 period. The social sciences showed the greatest numerical increase in 1974 as compared to 1967—80 percent—and the physical sciences the least—4 percent.

S/E doctorate projections indicate the expectation of a continuation of the differences observed in the recent past between the 5 individual broad S/E fields. In both the Probable and the Static projections, doctorates in the social sciences are estimated to increase in number steadily through 1985, and doctorates in the physical sciences to decrease. By 1980 in both the Probable and the Static projections, the social sciences component of S/E doctorates will have risen to 37 percent, and the physical sciences component dropped to 14 percent. In 1985 in both projections the social sciences are expected to make up 42 percent of all S/E doctorates and the physical sciences only 10 percent (table B-3).

Trend and Projection Relationships

BACCALAUREATES

Baccalaureates in S/E fields as a percent of the 22-year-old population rose from 4 percent in 1955 to 8 percent in 1972, and are projected to rise steadily, to the 8.5 percent to 10-percent level by 1985 (chart 7). As a proportion of the average number of college entrants four and five years earlier, S/E baccalaureates have recently declined to 17 percent from a high point of 19 percent in 1968, but are expected to rise over the projected period to the 20-percent level as a result of the growth anticipated in social science and life science baccalaureates (table B-2).

Annual production of S/E baccalaureates in 1980 and 1985 is expected to be over 20-percent higher than that of 1972 (both projections). Total S/E baccalaureate production over the period 1973-85 is projected to exceed that of the preceding period of comparable length by 74 percent (Probable projection). This pattern of growth will occur as the result of increases in the projected period as compared to the preceding period in the population of the appropriate age-group; in the proportion of college entrants achieving the baccalaureate (and/or a first-professional degree); and in the proportion of baccalaureates falling in S/E fields.

ENROLLMENT FOR ADVANCED DEGREES

Total S/E enrollment for advanced degrees over the entire projected period is expected to exceed that of the preceding period of comparable length by 19 percent (the Probable projection) to 42 percent (the Static projection). These increases are a reflection of increases in the size of the population aged 23 to 29—the traditional graduate-student-age population—which will be considerably larger in the projected than in the preceding period. The 1980 population in this age-group, for example, will be over 1-3/4 the size of the comparable group in 1960; the 1985 population aged 23 to 29 will be 1-3/4 times that of 1965. Increases anticipated in S/E enrollment for advanced degrees will thus fall far behind increases in the 23- to 29-year-old population.

As a percent of the 23- to 29-year-old population in the same year, S/E enrollment for advanced degrees rose from 0.8 percent in 1960 to 1.2 percent in 1965 and remained at the 1965 level until 1972, when it dropped to 1.1 percent.[6] *Probable* S/E enrollment for advanced degrees is projected to fall from the 1.1-percent level of 1972 to 0.9 percent in 1980 and 0.7 percent in 1985; *Static* S/E enrollment for advanced degrees is estimated to remain at the 1.1-percent level of 1972 over the projected period (table B-1).

[6] Enrollment for advanced-degrees data for 1972 were not available from NCES in time to be utilized in the development of the enrollment for advanced-degrees projections presented here.

DOCTORATES

In the relationships between S/E doctorates and other data of interest to S/E higher education, S/E doctorate data for 1973 and 1974 show the continuation of declines begun in 1971 or 1972. As a percent of first-time S/E enrollees for an advanced degree[7] seven years earlier, S/E doctorates began to decline in 1971 and dropped further in 1973 and 1974; as a percent of S/E baccalaureates eight years earlier, S/E doctorates began to decline in 1972 and continued to drop in 1973 and 1974. Similarly, S/E doctorates as a percent of 30-year-olds in the population in the same year declined from the 1970-72 level of 0.7 percent to 0.6 percent in 1973 and 1974. These declines are expected to continue over the projected period, as can be seen from the Probable projections for 1980 and 1985 (tables B-1 and B-2).

Among men, the growth in number of S/E doctorates between 1967 and 1972 in all S/E fields together and in each S/E field except the physical sciences was nearly twice as great as the corresponding growth in the number of 30-year-old males in the population. Between 1972 and 1974, however, while the male 30-year-old population increased by 7 percent, the number of men S/E doctorates *declined* by 6 percent. In 1980, when the number of male 30-year-olds will be 23 percent greater than the number in 1974, male S/E doctorates are expected (*Probable* projection) to be 4 percent *fewer* than in 1974. And in 1985, when the number of male 30-year olds will be 40-percent higher than the number in 1974, male S/E doctorates (Probable projection) are expected to be *16 percent fewer* than in 1974.[8]

Over the projected period 1975-85, total S/E doctorate production will range from 19 percent to 43 percent greater than that in the preceding period of comparable length, as the result of increases in the size of the population of the age of doctorate-level education. This will occur in spite of recent and projected decreases in levels of involvement in S/E doctorate education. The sharp contrast, however, between the 46-percent rise which will occur in the 30-year-old population over the projected period and the anticipated rise of only 19 percent in the number of Probable S/E doctorates in the same period illustrates the effect of recent and projected downward trends in S/E higher education on the projections of the Probable model.[9]

[7] See table B-7 for numbers of first-time enrollees for advanced degrees in S/E fields.

Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P-25, Nos. 519, 529, and 541 (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office).

[8] See appendix A for detailed methodology and tables within it which illustrate the declines in rates of participation and continuation at various stages of S/E higher education which have occurred in the recent past and which are projected for the future in the Probable Model.

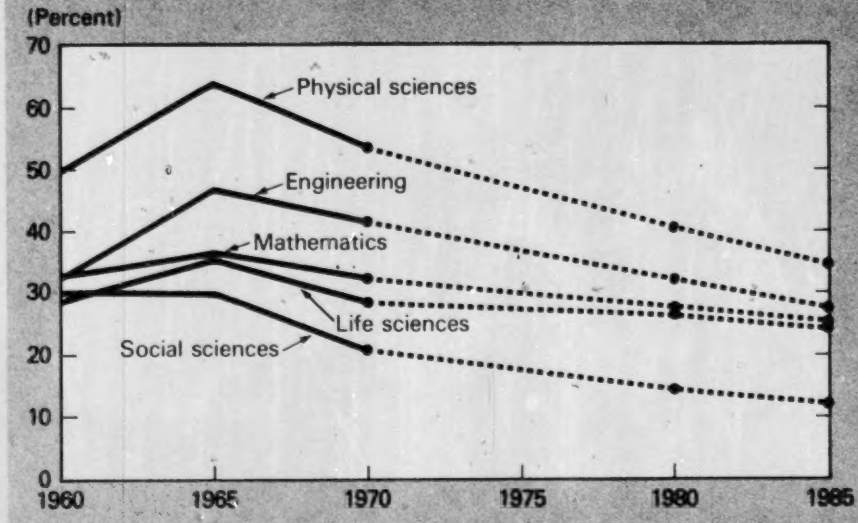
Chapter IV. SUMMARY OF MAJOR TREND RELATIONSHIPS IN S/E HIGHER EDUCATION, PAST AND PROJECTED

The projected involvement in higher education in S/E fields for 18-year-olds of 1972 is substantialiy different from the rates of S/E higher education achievement observed among the 18-year-olds of 1960. For the 1972 group, the Probable projections indicate that, of every 1,000 18-year-olds, 460 will enter college, 80 will achieve S/E baccalaureates, 20 will enter S/E advanced-degree study, and 4 will earn S/E doctorates (chart 8).

In the 1960 group, by comparison, only 360 of every 1,000 entered college and only 60 acquired S/E baccalaureates. Twenty, the same number projected for the 1972 group, entered S/E advanced degree study, however, and seven, in contrast to the four of the 1972 group, acquired doctorates in S/E fields. From the point of view of the Probable projections, then, the output of highly trained S/E manpower per person of college-entrance age and, especially, per college entrant will decrease significantly for the population aged 18 in 1972 as compared to the population of the same age in 1960.

Similar evidence of a decline in rates of continuation from one stage to the next in S/E higher education can be seen from recent changes in the following: (1) the percentage relationship between first-time enrollment for advanced degrees in each S/E field and baccalaureates in the same field in the preceding academic year; and (2) the percentage relationship in successive years between doctorates in each S/E field and first-time advanced-degree enrollment in the same field seven years earlier (charts 11 and 12).

Chart 11. First-time enrollment for science/engineering advanced degrees as a percent of baccalaureates in same field in preceding academic year: selected years 1960-70 and Probable projections for 1980 and 1985



Note: Dotted lines from 1970 to 1980 and 1985 serve only to connect the actual data with the projections and should not be interpreted as representing projected values for the intervening years.
SOURCES: Baccalaureate data through 1970, National Center for Education Statistics (HEW); first-time advanced-degree enrollment, estimated by National Science Foundation; projections, National Science Foundation (tables B-7 and B-8).

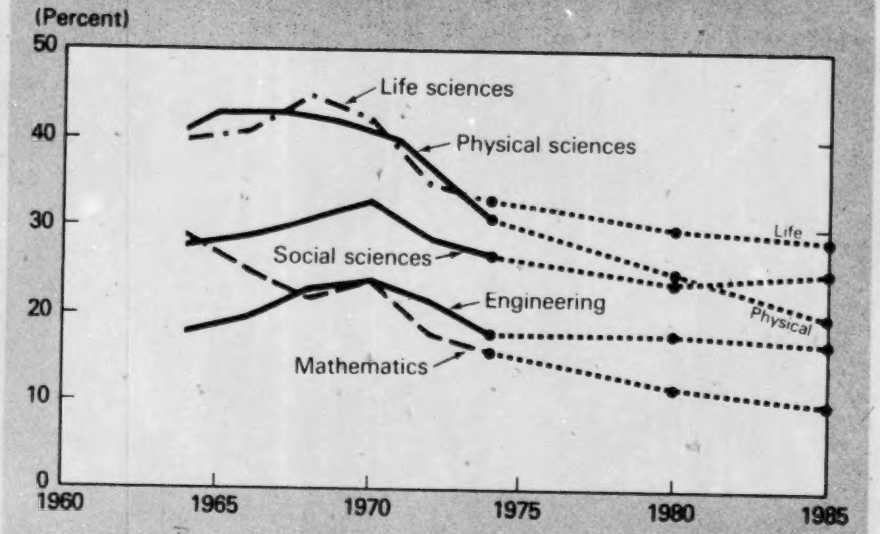
First-time enrollment for advanced degrees as a percent of baccalaureates in the preceding year was higher in 1965 than in 1960 in all S/E fields except the social sciences. In all five S/E fields, however, declines in this relationship occurred between 1965 and 1970. For all fields the Probable projections indicate further decreases in the relationship by 1980 and 1985, as the result of the lower rates of entrance into advanced-degree study which will occur over the projected period in the Probable projections. (See table B-8 and also detailed methodology and related tables in appendix A.) In the Static projections, the relationship between first-time S/E enrollment for advanced degrees and baccalaureates in the same field in the preceding academic year will rise by 1980 to a point higher than that of 1970 for one field only—the life sciences—and will increase still further in that field by 1985.

Over the period 1964-74 the relationship between the number of doctorates in each of the five major S/E fields and the number of first-time enrollees for an advanced degree in the same field seven years earlier varied from field to field. The relationship ranged from 40 percent to 45 percent for the physical sciences and the life sciences (during most of the period) to 18 percent to 24 percent for engineering (table B-9).

In all fields the magnitude of this doctorate to first-time enrollment for advanced degrees relationship declined during the last four to six years of the 1964-74 period. In the mathematical sciences the decline was a continuation of one that had been going on throughout the period. In the other four S/E fields, the relationship grew during the early years of the period, reached a high point at some time between 1968 and 1970, and then declined. By 1974 the relationship in all fields was at or below the level of 1964. The most marked decline occurred in the mathematical sciences, where the 1974 rate was only slightly over one-half that of 1964. Among the four fields in which the relationship rose during the early years of the period, peaked, and declined, the smallest rate of decline between the peak relationship and the 1974 relationship took place in the social sciences, the largest in the physical sciences.

In the social sciences, the life sciences, and engineering the 1980 and 1985 rates for this relationship projected by the Static method are higher than the 1974 rate. In the physical and mathematical sciences, however, the Static projected rates for 1980 and 1985 are lower than the 1974 rates. In the Probable projections in all fields, the 1980 rates are at or below the 1974 rates and the 1985 rates are below the 1974 rates.

Chart 12. Doctorates as a percent of first-time advanced-degree enrollees in science/engineering fields 7 years earlier: selected years 1964-74, and Probable projections for 1980 and 1985



Note: Dotted lines from 1974 to 1980 and 1985 serve only to connect the actual data with the projections and should not be interpreted as representing projected values for the intervening years.

SOURCE: Degree data through 1971-72, National Center for Education Statistics (HEW); degree data for 1973 and 1974, National Academy of Sciences — National Research Council and National Science Foundation; estimates of first-time enrollment for advanced degrees and projections, National Science Foundation (tables B-7 and B-9)

APPENDIXES

A. Technical Notes

B. Statistical Tables

C. Bibliography

APPENDIX A
Technical Notes

Components of Fields of Science

Physical Sciences: Includes chemistry, earth science, physics, geology, meteorology, astronomy, metallurgy, geophysics, pharmaceutical chemistry.

Engineering: Includes aeronautical, architectural, biomedical, ceramic, chemical, civil, electrical, engineering sciences, environmental health engineering, geological, industrial, mechanical, mining, nuclear, petroleum, and all other forms of engineering.

Mathematical Sciences: Includes mathematics, statistics, computer sciences, data processing, systems analysis, and all related fields.

Life Sciences: Includes agriculture (except agricultural economics), forestry, biology, botany, zoology, ecology, embryology, entomology, genetics, nutrition, plant pathology, plant physiology, anatomy, biochemistry, biophysics, microbiology, pathology, pharmacology, physiology, and related fields.

Social Sciences: Includes agricultural economics, geography, econometrics, anthropology, archeology, economics, linguiistics, sociology, government (political science), demography, and psychology. (Does *not* include history, education, social work, public administration, or other applied fields.)

Nonscience: All other fields.

Overview of Projection Model

The projections of this report were developed via a five-matrix demographic model tracing and reproducing for the past the flow of students through five stages of the higher education process—from college entrance to the attainment of the doctorate—and employing time-series analyses, trend projections, and extrapolative forecasting techniques to develop data estimates for the future. At each stage of the higher education process—entrance into college, acquisition of the baccalaureate, entrance into graduate study, retention in graduate study, and attainment of the doctorate—the model provides for each sex historical data and two sets of projections, to the year 1985, of the number of students involved and the percent and number of students completing the stage and proceeding to the next. Throughout its development, the model has met the pragmatic test of reproduction of past data.

The two sets of projections, called Probable and Static, are based on the major trends in science and engineering higher education observable in the most recent 10-year period for which data are available for each stage of the higher education process. The Probable and Static projections differ as follows: The Static projection gives equal weight to (1) the upward trends of the earlier years of the 10-year period in rates of participation and continuation in science and engineering higher education and (2) the downward trends of the later years of the period. The Probable projection gives double weight to the trends of the later years of the period, in combination with those of the earlier years. (See chapter II for the differences in assumptions and rationale in the two projections.) Each set of projections adheres to the trend-weighting system as described at all stages of the projection model, except as noted below, and, at each stage after the first, reflects the cumulative effect of the application of the system at the earlier stage(s) of the model.

Data are provided and projected by S/E field as well as by sex from the baccalaureate stage on, the fields numbering five—engineering and the four broad science fields of the physical sciences, the mathematical sciences, the life sciences, and the social sciences. The last three matrices of the model, all of which deal with study beyond the baccalaureate level, are made up of 10 basic components each, one for each sex in each of the five S/E fields.

Methodology in Detail

The following is a detailed description of the application of the model technique at each stage of the higher education process covered by this report. The discussion of each matrix of the model consists of a general statement of the material involved in the matrix, followed by a more detailed description of the development and the sources of the material. Each of the five matrices of the model is made up of the following:

A. *Input* (numbers)

B. *Rate of completion of stage of education* covered by matrix (percentages) Note: There is no completion rate of this type in Matrix IV.

C. *Pattern (time-spread) of completion* among those who complete (percentages)

D. *Output* (numbers)

Matrix I. Entrance into College—18-year-olds to college entrants.

For each of the age-18 population cohorts of the period 1944-72, rates of entrance into college were ascertained for each sex and projected to 1985 by the use of time-series data and trend projections based on the rates of the last 10 years for which data are available. Probable and Static projections were developed on the basis of the trend-weighting system described in the Overview of Methodology section of this report.

In this phase of the model, a time-pattern of entrance into college is used, which displays, for those from each population cohort who enter college, the proportion entering at age 17, age 18, age 19, and subsequent ages. This pattern, or "spread" of entrance, appears to have remained virtually static for each sex, except for a variation for males for brief periods in war and/or postwar years, and is held constant for the future. (See C. under Detail below for sources of information.)

The total number of entrants into college for each projected year is obtained by summing the numbers of entrants in that year from all relevant age-cohort groups. Four Matrices I were developed for this stage of the model, a Probable and a Static for each sex.

DETAIL

A. *Input—number of 18-year-olds* by sex, past and projected (1945-1986). Source: U.S. Bureau of the Census, *Population Estimates and Projections* publications[1] current at time this phase of model was developed. (No birth projections were involved here; all population cohorts of interest had already been born.)

[1] Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P-25, Nos. 311, 385, 411, 441, and 470 (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office).

B. *Rate of entrance into college*, i.e., percent ever entering college

1. Source of data for cohorts of past: U.S. Bureau of the Census, *Educational Attainment* survey reports showing percent of specific population age-cohorts (by sex) acquiring a year or more of college over time. These percentages were adjusted slightly, for each cohort, to:

a. include those who entered college but did not complete the first year (this adjustment constituted a relative 10-percent increase in rate)

b. provide, in the case of cohorts under age 40, for those who would enter college later in life (this can be judged from the entrance patterns of earlier population cohorts, i.e., from the extent to which, among earlier cohorts examined over time by the *Educational Attainment* survey, the "percent completing a year or more of college" (U.S. Bureau of the Census category) increased after conventional college entrance age)

c. fit the constraints of actual historical data from the National Center for Education Statistics (NCES) on number of college entrants in past years, when combined with the pattern, or horizontal spread, of entry into college described in "C" below. (This adjustment in "rate of entrance," if and when made for any given year of the past, constituted an absolute ±1- to 2-percent change and was made to achieve as close approximation as possible to NCES's number of entrants for that year.)

2. Projection of rates for each cohort in future years through 1986 - Probable and Static projections were developed on the basis of the rates of the trend lines of the early and of the later years of the last 10, using straight-line least squares regression techniques, with projection results weighted differentially for Probable and Static projections, as described above in the Overview of Projection Model section of this appendix.

C. *Pattern or horizontal spread of entry into college*, i.e., time of college entry of those from a population cohort who will ever enter.

Sources: (1) American Council on Education annual freshman *National Norms* publications, 1961-72; (2) *Education and Employment*, Laure M. Sharp, The Johns Hopkins Press, 1970; (3) *Two Years After the College Degree*, National Science Foundation, (NSF-63-26) 1963; (4) *The Educational and Vocational Development of College Students*, Astin and Panos, American Council on Education, 1969; (5) *The Seniors of 1964*, unpublished report of National Opinion Research Council prepared for the National Science Foundation; (6) *Project Talent Five-Year Follow-Up* of high school seniors of 1960; (7) National Center for Education Statistics, HEW *Longitudinal Study of High School Seniors of 1972*; (8) U.S. Bureau of the Census periodic *Educational Attainment* surveys - these provide data over time on specific population cohorts which indicate the percent of the cohort completing a year or more of college by certain ages, from age 18 to 19 on over the lifetime of the cohort.

D. *Output - number of college entrants*, i.e., first-time degree-credit students, for past years and projected years through 1985. Total for each year is calculated by summing those numbers from all population age-cohorts who are expected to enter college in that year.

Matrix II. Attainment of Bachelor's and First-Professional Degrees—Number of college entrants to number of bachelor's and first-professional degrees.

For college entrants of the two-decade period ending fall 1967, rates of completion of undergraduate and first-professional degree education were ascertained for each sex in relation to the numbers of bachelor's and first-professional degrees earned through 1970-71 (the latest year for which degree data were available from the NCES at the time this matrix was developed). Rates of completion for entrants into college after 1967 were then projected to 1985 on the basis of the completion rate of male college entrants of the last five entrance years for which data were available, in accordance with the following rationale:

At this particular stage of the higher education process, there has been no observable recent change in the direction of long-term trends. The rate of attainment of bachelor's and first-professional degrees among male college entrants, for example, has displayed only minor variation for the last 15 years and has remained completely static for the last five years at a rate slightly higher than that of the preceding five years. It was decided, therefore, to maintain the rate for men constant through 1985 at the level prevailing for the last five years. (See B. under Detail below.) Among women, the rate of attainment of bachelor's and first-professional degrees has been rising, but has not as yet reached that of males in recent years. The gap between the two is relatively small, however, and it is assumed that in 1985 the rate for women will be the same as that for men. The rate for women was increased gradually from the last observed rate to the same rate as that for men by 1985. (See B. under Detail below.)

For those from each year's cohort of college entrants of each sex who will achieve the baccalaureate, a time-pattern, or "spread" of completion of this stage of higher education is utilized, to provide for variations between individuals in number of years elapsing from entrance into college to the acquisition of the degree. This spread has remained constant, as far as could be ascertained, for each sex and was held in the same patterns for the future.

The total number of bachelor's and first-professional degrees for each projected year is obtained by summing the numbers of such degrees earned that year by members of each relevant entrance cohort. This matrix of the model yields Probable and Static projections of numbers of bachelor's and first-professional degrees based not on differing projected rates of attainment, but on the differing Probable and Static *inputs* of college entrants of each sex into this phase of the model. Four Matrices II are developed at this stage of the model, a Probable and a Static for each sex.

DETAIL

A. *Input—number of college entrants* (i.e., first-time degree-credit enrollees) for past through 1972 (NCES, HEW); NSF projections, from Matrix I, for 1973-1985.

B. *Rate of completion of college*, i.e., percent of each entrance cohort which ever achieves a bachelor's or first-professional degree.

1. Sources for rates of completion for college entrance cohorts of past: comparison, via moving average, of number of actual baccalaureates and first-professional degrees (NCES) in a given period with number of actual entrants (NCES) of a given period four years earlier. Rates produced by this comparison are subject for any given year to such minor adjustment as necessary (± an absolute 1 percent to 2 percent) to fit constraints of actual NCES historical data when used in combination with the pattern or horizontal spread of completion of baccalaureate (see "C" below). (This adjustment in rate of completion for any given year was made to achieve as close approximation as possible to NCES's numbers of baccalaureates of past years.)

2. Projections of rates for future—Rate for men being held for future at the constant level of the most recent five actual years for which completion data are available; rate for women, which has been rising gradually over the observed period, but has not ever reached that of men, is moved up gradually to equal that of men by 1985. Rationale for holding attainment rate of men at constant level of most recent five years: changing characteristics and composition of more recent college entrants, for whom no completion data are available, do not warrant projecting completion rate on the basis of

the slightly upward trend line of the data of the last 10 years. These characteristics are: increasing proportions of college entrants (1) entering 2-year rather than 4-year colleges, (2) enrolling on a part-time rather than full-time basis, and (3) falling in age-groups beyond those of traditional college entrants or undergraduates. (See *Fall Enrollment in Higher Education, 1972*, National Center for Education Statistics, HEW, and *Advance Report of October 1974 School Enrollment*, U.S. Bureau of the Census.) Since these characteristics have been notable among recent women entrants as well as among men, it was decided to project women's rate of attainment for 1985 to a point equal to but not higher than men's for that year. (If the rate for women had been projected to 1985 on the basis of the slightly upward trend-line of the last 10 years, women's 1985 rate would have been slightly higher than that being used in both models for men for that year.) Women's rates have been set at a level equal to men's by 1985 also because it is assumed that as women participate in greater numbers and proportions in higher education, their behavior will tend to approach that of the norm or the total population engaged in the particular stage of higher education.

C. *Pattern or horizontal spread of completion of college*, i.e., of those who complete, percent doing so within certain numbers of years after entrance. Sources: *Four Years After College Entry*, Bayer (1972); *Five and Ten Years After College*, El-Khawas and Bisconti (1974); *Undergraduate and Graduate Study in Scientific Fields*, Bisconti and H. Astin (1973), American Council on Education; items (2)-(6) listed in I., C., above as sources of information on pattern or horizontal spread of entry into college.

D. *Output—total number of bachelor's and first-professional degrees, by sex*, for the past through 1970-71; projections, *Probable* and *Static*, of number of such degrees through 1984-85. Total number of degrees for each year is calculated by summing those from each college entrance cohort who are expected to achieve the baccalaureate in that year.

E. *Disaggregation by field* of total bachelor's and first-professional degrees for projected years.

The total number of bachelor's (and first-professional) degrees in all fields projected for each sex via Matrix II for any given year was disaggregated by field on the basis of a projection of the *percent* of bachelor's degrees which would fall in each of the major fields in the given year. This projection of percent of bachelor's degrees by field was calculated for each sex separately on the basis of trends in the percent of degrees falling in each of the major science and engineering fields in the most recent 10 years for which bachelor's degree data were available—the 10-year period ending 1971-72. Probable and Static projections of *percent* of degrees to be constituted by each field were made on the basis of the usual Probable and Static trend-weighting system. The number of bachelor's degrees in S/E fields projected for any given year was subtracted from the total of all bachelor's and first-professional degrees projected for that year; the number of degrees remaining was considered the number expected to fall in the "all other" field category in that year. (See table B-4.)

Note regarding sex-fields in which there was a departure from some aspect of the standard disaggregation method:

1. Engineering—Men - In this sex-field, information from the Engineering Manpower Commission of the Engineers Joint Council on the numbers of baccalaureates in engineering in 1972-73 and 1973-74 and on the magnitude of undergraduate enrollment in engineering programs made it possible to make estimates of the numbers of engineering baccalaureates through 1977-78 and to project numbers of male engineering baccalaureates to 1985 on the basis of these additional years of data beyond 1971-72.

2. Physical sciences (both sexes)—In this field for each sex the proportion of total bachelor's degrees constituted by the field had been decreasing steadily throughout the observed period. When this trend was extrapolated to the latest projected year, 1985, the percent of degrees falling in the field in that year—and the numbers of degrees that would have resulted from the application of the extrapolated percentages to the total number of bachelor's degrees projected for the year—seemed unrealistically low. It seemed unreasonable to assume that the declines in the proportion of degrees constituted by this field for each sex would continue at recently observed rates; it was arbitrarily decided therefore to use, as the percent of degrees projected to fall in the field by 1984-85, a point *halfway* between the last actual observed percentage of degrees falling in the field and the percentage point projected for 1984-85 by the full force of the regression used in the extrapolation process.

Matrix III. Entrance into Study for an Advanced Degree—Number of S/E baccalaureates by sex-field to number of first-time enrollees for an advanced degree in the sex-field.

For baccalaureate cohorts of the 15-year period ending 1970-71, rates of entrance into advanced-degree study were developed for each of the five broad S/E fields, for each sex. Corresponding rates to 1985 were projected by the use of time-series data and extrapolative forecasting techniques, using the rates of the last 10 years for which data were available. Probable and Static projections were developed on the basis of the trend-weighting system already described.

In this phase of the model a time-pattern of entrance into graduate study is utilized for each of the 10 S/E sex-fields, which displays, for those from each baccalaureate cohort entering study for an advanced degree, the percent who enter within specified numbers of years after acquisition of the baccalaureate. Within each of the sex-fields except one, this pattern or "spread" of entry, has remained constant in the past and is held constant for the future.

The total number of entrants into advanced-degree study each year for each sex-field is obtained by summing the numbers of entrants from each of the relevant baccalaureate cohorts. (Twenty Matrices III were developed for this stage of the Model, a Probable and a Static for each of the 10 S/E sex-fields.)

DETAIL

A. *Input per sex field* - number of baccalaureates (NCES) for years 1948-49 through 1971-72; NSF projections of baccalaureates for the sex-field through 1984-85. Exception: Men *Engineering* - as has already been indicated, NSF estimates (based on Engineering Manpower Commission-Engineers Joint Council data) of the number of baccalaureates to be earned through 1977-78 and NSF projections through 1984-85 are used here.

B. *Rate of entrance into advanced-degree study*, i.e., percent of each annual baccalaureate cohort in a field, past and projected, which enters study for an advanced degree in the field.

Ideal information for use in the determination of this rate would be annual data on number of first-time enrollees for an advanced degree by sex and graduate field and, if possible, by undergraduate field and year of undergraduate degree. If this kind of information were available, it could be related to the number of baccalaureates in the sex-field in the several preceding academic years in the same way that data on college entrants are related to number of 18-year-olds in matrix I or number of baccalaureates to number of college entrants in matrix II.

Such information is not, however, available. Estimates, therefore, had to be made of the number of first-time graduate

---

No data on enrollment for advanced degrees in fall 1972 were available from NCES, HEW, at the time this phase of the model was developed.

students in past years and of the proportions of S/E baccalaureate cohorts of the past who entered graduate study. (Estimation assumptions and methods will be discussed immediately below, in the section beginning "Assumptions made and procedures used. . .") The adequacy of these estimates and of the numbers of first-time S/E graduate students they produced in this Matrix for the years of the past (when combined with the time-pattern of entrance into graduate study to be described in Section "C" below) was then tested in the two later matrices of the model—IV and V—where the numbers produced by Matrix III serve as input. The results of these tests were satisfactory with respect to reproduction of the past for both total enrollment for advanced degrees (Matrix IV) and number of doctorates (Matrix V), where actual NCES data series are available for comparison with the products of the matrices.

Assumptions made and procedures used in making estimates for this matrix:

1. Procedure for estimating the number of *first-time* enrollees for an advanced degree in a sex-field from the number of *first-year* enrollees reported by NCES for past years in *Enrollment for Advanced Degrees* annual surveys:

Note: The category of *first-year* graduate-degree enrollee at the opening of any given school term includes not only *first-time* graduate-degree students but also those who have earned some graduate credits previously but have not as yet completed the equivalent of two full-time semesters or three full-time quarters of study for an advanced degree.

It was assumed that 90 percent of first-year full-time enrollees and 30 percent of first-year part-time enrollees were *first-time* graduate-degree enrollees.

Rationale and bases for these assumptions:

a. The assumption that 30 percent of part-time first-year enrollees are *first-time* enrollees is made on the basis of the method used by the National Center for Education Statistics to calculate full time equivalency. (See NCES annual *Opening Fall Enrollment* surveys, especially *Opening Fall Enrollment 1972.*)

This method counts three part-time enrollees as the equivalent of one full-time enrollee. On this basis, it is assumed that part-time students carry only one-third of a normal load and take three years to finish the work of a normal academic year. Thus in any given year, only one-third of part-time "first-year" enrollees will be *first-time* students.

b. The assumption that approximately 90 percent of full-time first-year graduate-degree students in S/E fields are probably *first-time* graduate enrollees was made on the theory that persons enrolled in graduate study in these fields on a full-time basis and classified as not as yet beyond the first year of such study are probably first-time students aiming to finish the requirements of the first year's graduate study within the academic year in which they are enrolled. The assumption was made also on the basis of data from: (1) followup studies of college seniors of 1961, especially *Longitudinal Studies on the Class of 1961: The Graduate Science Students*, NORC, 1967; (2) *Two Years After the College Degree*, National Science Foundation (NSF 63-26), 1963; (3) *Education and Employment*, Laure M. Sharp, The Johns Hopkins Press, 1970; (4) *Graduate Student Finances 1963*, NORC, 1965; and (5) NCES (HEW) *Enrollment for Advanced Degrees* data described immediately below.

In fall 1971 for the first time and in fall 1972 again, the NCES obtained from some schools, as part of the annual enrollment for advanced degrees survey, data on the number of full-time and part-time *first-year* students who were also first-*time* students.[3] Data supplied by schools where most graduate students in S/E fields are enrolled in the "traditional" way, i.e., on a daytime, full-time basis, support the assumption that 90 percent of first-year full-time graduate enrollees are *first-time* graduate enrollees. At the University of North Carolina at Chapel Hill, for example, in fall 1971, 90 percent to 100 percent of men and of women enrolled full-time as first-year enrollees for an advanced degree in the physical sciences, engineering, and psychology were reported as being *first-time* graduate enrollees. (The percent varied from field to field). Similarly, at the University of Massachusetts at Amherst, in both fall 1971 and fall 1972, among first year full-time men graduate enrollees in the physical sciences, engineering, mathematics, and psychology, from 83 percent to 100 percent were reported as *first-time* enrollees for advanced-degree study.

As for first-time versus first-year part-time enrollment, the random choice of Michigan State University from among those schools reporting first-time enrollment in fall 1971 and having part-time enrollment for advanced degrees in numbers large enough to make a comparison between first-year and first-time, yielded data which give support to the assumption that approximately 30 percent of part-time first-year graduate enrollees are *first-time* graduate students. Among men graduate enrollees at that institution in mathematics, psychology, and engineering, *first-time* part-time enrollees constituted from 29 percent to 38 percent of first-year part-time enrollees.

2. General assumptions regarding estimating the proportion of succeeding baccalaureate cohorts ever entering graduate study in S/E fields:

a. It was assumed that the number who would ever enter graduate study from the baccalaureate cohort of academic year x in a given sex-field would be roughly the equivalent of the average number of *first-time*[4] enrollees for an advanced degree in that sex-field in academic years $x+1$ and $x+2$. (Rationale: A very high proportion of those ever entering study for an advanced degree in S/E fields do so in the first and second years after acquisition of the baccalaureate. Also, in any given cohort of graduate entrants in S/E fields, a high proportion comes from baccalaureates of the preceding two academic years. *Sources: Undergraduate and Graduate Study in Scientific Fields*, ACE Research Reports, 1973; annual tabulations of background data on doctorates, NAS-NRC; *Five and Ten Years After College Entry*, ACE Research Reports, 1974.) This assumption is necessarily a contraction or condensation. It is a simplifying device that assumes that the average number of *first-time* graduate students of years $x+1$ and $x+2$ who do *not* come from the baccalaureates of year x is the rough equivalent of those members of baccalaureate cohort x who will enter advanced degree study later than two academic years after the acquisition of the baccalaureate.

b. A comparable simplifying assumption is made with respect to the undergraduate field of enrollees for advanced degrees in S/E fields. As a device for organizing and collapsing data for the past, it is assumed that all graduate students in a field obtained their baccalaureates in the field in which they are enrolled for graduate study. This assumption is made partly because in the science fields other than the social sciences a very large proportion of enrollees for advanced degrees have taken their undergraduate degree in the same science field[5] and also because the establishment of a

[3] Unfortunately, many colleges and universities did not respond to this question at all, so no reliable national data are available for this item.

[4] For method of estimating number of first-time graduate enrollees, see 1, immediately above.

[5] "Undergraduate and Graduate Study in Scientific Fields," ACE Research Reports, in the social sciences, over one-half of enrollees for advanced degrees (58 percent) have earned their undergraduate degrees in the social sciences.

statistical trend in the ratio of graduate entrants to baccalaureates is not contingent upon students' enrolling for a graduate degree in the same field in which they took their baccalaureate. Rates of entrance into graduate study of baccalaureate cohorts by sex-field used in the projection model for past years through 1970-71 are thus not necessarily "true" in all sex-fields for the baccalaureate cohort to which they are related, but are "working" rates which produce numbers of first-time advanced-degree students for years of the past close to those estimated via the method described in section 1 above. These numbers of first-time enrollees, when fed into matrices IV and V, result in numbers of total enrollees for advanced degrees (total enrollment for advanced degrees) and of doctorates for a period of the recent past which are close to past actual NCES data for those years.

Projection of *rates* of entrance into advanced-degree study of S/E baccalaureate cohorts of 1971-72 to 1984-85 was accomplished by using the rate-of-entrance data of the most recent 10 years, developed as described above, and the trends observable in this data, to project, for each sex-field, the percent of baccalaureates of 1984-85 who would enter such study. The upward trends of the early part of the most recent 10 years and the downward trends of the later years were weighted differentially in combination with each other to produce the two projections—Probable and Static—for each cohort of the projected period. Tables A-1 and A-2 show the developed and projected rates for men and women, respectively, in the five S/E fields.

C. *Pattern of entrance into study for an advanced degree in S/E fields.*

It was assumed that, of those ever entering study for an advanced degree from a given baccalaureate cohort, approximately three-fourths would enter within two years after the acquisition of the baccalaureate. The remaining one-fourth of entrants from each cohort are assumed in the model to begin their graduate study within three, four, five, or six years after the baccalaureate. (Here again, there is of necessity some small degree of collapsing of data, i.e., those who enter graduate study seven or more years after the baccalaureate are included among those who enter six years after.)

Sources: *Five and Ten Years After College Entry*. ACE Research Reports, 1974; *Undergraduate and Graduate Study in Scientific Fields*. ACE Research Reports, 1973; "Longitudinal Studies on the Class of 1961: The Graduate Science Student," NORC, 1967; *Two Years After the College Degree*. National Science Foundation (NSF 63-26), 1963; *Education and Employment*. Laure M. Sharp. The Johns Hopkins Press, 1970; *Graduate Student Finances, 1963*. NORC, 1965.

D. *The total number of entrants into advanced degree study* in a sex-field in a given year is calculated by summing the numbers from each pertinent baccalaureate cohort who enter advanced-degree study in that year.

Matrix IV. Magnitude of Total Advanced-Degree Enrollment in Each S/E Field—Entrants into advanced-degree study to total number of enrollees for S/E advanced degrees

For entrants into advanced-degree study in each S/E field in the period 1955 to 1971, patterns of retention in such study were developed for a number of years—typically six—after initial entry. The percentage of entrants who remain enrolled for specified numbers of years may differ from field to field, for each sex, and over time. The retention patterns most recently observed for each sex-field were extended into the future. (See Detail below for caveat.)

The total number of enrollees for advanced-degree study in a sex-field in any given year from 1960 to 1985 was obtained by summing the numbers from each cohort of entrants who, in that year, were enrolled in such study. At this stage of the model no historical trends or trend projections are used or developed, and differing Probable and Static projections result, in each sex-field, from the differing Probable and Static inputs into this phase of the model, these inputs being the numbers of entrants into advanced-degree study developed as the end-product of Matrix III. (Twenty Matrices IV were developed for this stage of the model, a Probable and a Static for each of the 10 S/E sex-fields.)

Note: The products of Matrix IV are an end in themselves and are not utilized in the development of Matrix V.

DETAIL

A. *Input - number of entrants into advanced-degree study*, developed via Matrix III, for past (1955-1971) and future years through fall, 1985. (For future years, both Probable and Static numbers of entrants from Matrix III are processed through Matrix IV).

B. *Rate of completion*

In this matrix, as was indicated in the description of the basic components of all matrices, there is no specific "completion rate" for the entering cohort of each year. Entrants are retained in advanced-degree study on the basis of a set of retention rates for specified numbers of years.

For the past, this matrix attempts to reproduce the *total* number of enrollees for advanced degrees by field reported by NCES for the years 1960-71. (Total enrollment for advanced degrees consists of enrollees in all stages of advanced-degree study—first-time, first-year, and all years beyond the first.) Projections of total enrollment for advanced degrees by field and sex in this matrix are the result of (1) the input of first-time graduate enrollees and (2) the retention rates used in the horizontal spread of the matrix as described in C below.

C. *Patterns of retention in graduate study*

For the period of the sixties it was assumed that in most S/E sex-fields 75 percent of entrants into graduate study returned to such study for some degree of enrollment for a second year, 60 percent for a third year, 45 percent for a fourth year, 30 percent for a fifth year, and 15 percent for a sixth year. For men in the physical sciences, the mathematical sciences, and engineering, higher retention rates were used—80 percent, 65 percent, 50 percent, 35 percent, 20 percent, and 10 percent for physical and mathematical sciences; 80 percent, 65 percent, 50 percent, 35 percent, 20 percent, 10 percent, and 5 percent for engineering. These retention patterns, when applied to the numbers of entrants into advanced-degree study developed via Matrix III, produced by sex-field total numbers of enrollees for each year of the period that were very close to those reported by NCES.

D. *Totals for each year in this matrix are obtained by summing the numbers from all entrance cohorts enrolled in study during that year.* Since there are no "rates of completion" for the entering cohorts of past years and therefore no projections of rate of completion for entering cohorts of future years in this matrix of the model, differing Probable and Static projections for each sex-field result from the difference in magnitude between the Probable and the Static numbers of entrants into advanced-degree study used as input into the matrix.

NOTES:

1. Some of the assumptions made here are of necessity condensations and contractions. Some graduate entrants, for example, do not do all their graduate study in successive years, but may drop out of study for some years and then return; some may remain in study, enrolled on a minimal basis, for more years than six. Total enrollment for advanced degrees as reported by NCES and as delineated here includes part-time as well as full-time enrollees, even if enrollees are taking as little as one course for advanced-degree credit. The presence

of many part-time enrollees, some of whom may remain in graduate study for years, accounts for the high degree of accuracy of results obtained in this matrix—i.e., the successful duplication of NCES data for the past—by the use of what may seem to be fairly high retention rates, even in fields where the proportion of graduate entrants who ever attain the doctorate is relatively low.

2. In all S/E fields for men except the life sciences, and in three fields for women—the physical sciences, the mathematical sciences, and the social sciences—annual retention rates had to be reduced by a relative 5 percent to 10 percent starting in 1969-71 (the year varied with the sex-field) in order to reproduce NCES advanced-degree enrollment for the sex-field for the years in question. This can be construed as a confirmation of informal anecdotal information received from some colleges and universities to the effect that since approximately the beginning of the seventies, graduate-degree enrollees in some S/E fields have been remaining enrolled after receipt of the master's degree in smaller proportions than they did in the sixties. In the model it is assumed that these lower retention rates will continue throughout the projected period.

Caveat: Since enrollment for advanced degrees retention rates for each S/E sex-field in both projections are held at the most recently observed rates, and since in some S/E sex-fields, these rates have prevailed for only the last two to three years of the observed period, rather than the entire period, total S/E enrollment for advanced degrees projections have a lower degree of certainty than other projections produced by the models used here. (The other projections assume the continuation of "time-spread" patterns which have been stable over the entire observed period of the past.)

Sources: Undergraduate and Graduate Study in Scientific Fields, ACE Research Reports, Vol. 8, No. 3, 1973; *Of Time and the Doctorate*, K. Wilson, Southern Regional Education Board, 1965; *Graduate Attrition at Berkeley*, Office of Institutional Research, University of California, Berkeley, 1972; *The Study of Graduate Education at Stanford*, Stanford University, 1972; *Attrition in Graduate School*, E. A. Hammel, Proceedings, Western Association of Graduate Schools Fifteenth Annual Meeting, March 1973; *Longitudinal Studies on the Class of 1961: The Graduate Science Students*, A. Berger, NORC, University of Chicago, 1967.

Matrix V Doctor's Degrees—Entrants into advanced-degree study to doctorates.

The rate of attainment of the doctorate was determined by S/E sex-field for cohorts entering advanced-degree study in the period of the midfifties to the mid- to-late sixties. (The period varies slightly from sex-field to sex-field.) The rate was developed by relating the number in each entering cohort to the number of doctorates earned in the field a specified number of years later. Doctorate data were available from NCES through 1971-72 and from NAS-NRC through 1973-74 (see Detail below).

In all S/E fields for men and in the physical and mathematical sciences and engineering for women, future rates of attainment of the doctorate were developed from time-series data and trend projections of past rates, utilizing the latest 10 data-points available for each sex-field. In accordance with the standard trend-weighting system already described, trends of the more recent years of the period for which data were available were given double weight in combination with the trends of the earlier years for the Probable projection, equal weight for the Static projection.

In the remaining fields for women, the life sciences and the social sciences, the use of the standard projection system—despite decreasing rates in the most recent years—would have yielded unrealistically high rates for 1985, compared to those for men, as a result of the large spurts of growth which occurred among women in the early years of the observed period in these fields. In the life sciences, for example, in the Static projection, the 1985 rate for women would have been 48 percent, as compared to 36 percent for men. It was decided, therefore, in the case of the life sciences and the social sciences, which are the largest fields for women in advanced-degree study, to assume that by 1985 women entrants into such study in these fields would attain the doctorate at the same rate as men; accordingly, the 1985 Probable and Static rates projected for men were arbitrarily assigned as the 1985 rates for women in these fields. (See Detail and Note below.)

Of those from each cohort of entrants into advanced-degree study who attain the doctorate, specific percentages of entrants in each sex-field are shown to acquire the degree within certain numbers of years after entry. This pattern or "spread" of acquisition of the degree, has remained constant in the past and is held constant for the future.

DETAIL

A. *Input - number of entrants into advanced-degree study by sex-field*, as developed via Matrix III for past years and projected years through 1985

B. *Rate of attainment of the doctorate*

This rate was developed for entrants of past years through 1965, 1966 or 1967 (the year varied with the sex-field) in relation to the number of doctorates (NCES data) in the sex-field a specified number of years after entrance into advanced-degree study.

The time-lapse used between entrance and doctorate for each sex-field is based on NAS-NRC data on median time-lapse (by field and sex) from graduate-study entry to the doctorate.

Source of doctorate data through 1971-72 is NCES. For the years 1972-73 and 1973-74 doctorate data consistent with the NCES data series were estimated from the number of doctorates reported by NAS-NRC for those years, on the basis of past relationships between numbers of doctorates reported by NCES and numbers reported by NRC for each S/E sex-field for the same years.

Note: In some sex-fields the average number of doctorates earned x and x + 1 years after entrance into graduate study (or x and x + 1 and x + 2 years after entrance), rather than the number of doctorates in one particular year, was used to develop the rate of attainment of the doctorate. It was necessary to do this in sex-fields where the numbers of doctorates are relatively small and may vary relatively widely from year to year.

Projected rates of attainment of the doctorate for entrants into advanced-degree study through 1985 were developed on the basis of the trends observable in past rates. Differing Probable and Static projections were developed by weighting differentially the upward trends of the early years and the downward trends of the later years of the period of the past for which data are available in each sex-field. *Note regarding minor exception:* In the smallest of the 10 S/E sex-fields, female engineering, the trends of the later years of the period for which data are available proceeded in an upward rather than a downward direction and were weighted equally with the trends of the earlier years of the period for both the Probable and the Static projections. Differing Probable and Static projections of numbers of Ph.D.'s in this sex-field resulted therefore not from differing rates of attainment used in the Probable and Static projections but from the differing Probable and Static numbers of entrants into advanced-degree study used as input into the Ph.D. matrix of the model.

C. *Pattern or horizontal spread of attainment of the doctorate*, i.e., time-spread of attainment of the doctorate among those from an entrance cohort who will ever attain the degree.

Source of data for time-spread: National Academy of Sciences-National Research Council special tabulations on proportion of doctorates in S/E sex-fields who attain the degree in given numbers of years after entrance into advanced-degree study.

D. *Output - number of doctorates*

The number of doctorates in a sex-field for a given year, past or projected, is arrived at by summing the numbers from each entrance cohort who achieve the doctorate in that year, as calculated on the basis of the rate of attainment of the doctorate for each entering cohort ("B" above) and the time-spread of attainment ("C" above).

Note: The standard method of rate projection in the Matrix, as described in "B" above, was used in all S/E fields for men and in the physical sciences, the mathematical sciences, and engineering for women. In the two remaining fields for women—the life sciences and the social sciences, which are the largest S/E fields for women in advanced-degree study—the Probable and Static rates of attainment of the doctorate calculated for *men* for 1985 in these fields were arbitrarily assigned to women for 1985 on the basis of the following rationale: The use of the standard projection system for women in these fields, as a consequence of some relatively large spurts of growth in women's rate of attainment in the early part of the period for which data are available, yielded higher rates for women than for men by the year 1985, in spite of the fact that in the later part of the period for which data are available, women's rates, like men's, have been dropping. Also, in actual experience, the rates for women in these fields have not as yet ever reached those for men. It seems reasonable to assume that as more women acquire baccalaureates and enter graduate study in these fields, increases in the rate of attainment of the doctorate among women on the scale of those of the early years of the period for which data are available will not re-appear and that the patterns of graduate student behavior among women will continue to approach those of men in the same field. Therefore, it was concluded that the assumption could be made that by 1985 the rate of attainment of the doctorate among women entrants into advanced-degree study in these fields would be the same as that for men. See tables A-3 and A-4 for rates of attainment of the doctorate in S/E fields, past and projected, for men and women, respectively.

Table A-1.—Estimated percent of men baccalaureates enrolling for an advanced degree, by science/engineering field and year of baccalaureate: selected years, 1958-71, and Probable and Static projections for 1980 and 1985

Year of baccalaureate	Percent				
	Physical sciences	Engineering	Mathematical sciences	Life sciences	Social sciences
1958	54	33	50	29	35
1960	58	35	46	32	36
1961	61	37	45	35	37
1962	66	43	45	38	38
1963	69	48	45	41	38
1964	70	50	45	42	38
1965	70	49	47	42	38
1966	70	50	48	36	35
1967	67	51	45	35	32
1968	62	50	43	32	28
1969	53	47	42	30	25
1970	53	42	40	30	24
1971	50	38	38	31	23
Projected:					
1980: Probable	37	30	32	27	17
Static	46	37	37	34	20
1985: Probable	29	25	29	25	13
Static	44	37	37	36	19

Source: National Science Foundation.

Table A-2.—Estimated percent of women baccalaureates enrolling for an advanced degree, by science/engineering field and year of baccalaureate: selected years, 1958-71, and Probable and Static projections for 1980 and 1985

Year of baccalaureate	Percent				
	Physical sciences	Engineering	Mathematical sciences	Life sciences	Social sciences
1958	23	87	18	24	17
1960	26	89	19	26	20
1961	28	90	20	27	21
1962	34	91	21	29	22
1963	40	92	21	31	22
1964	43	92	22	33	23
1965	46	92	24	33	23
1966	51	92	25	33	23
1967	58	92	27	34	22
1968	53	92	25	34	21
1969	50	92	24	33	18
1970	54	92	22	31	17
1971	51	92	20	30	16
Projected:					
1980: Probable	54	92	17	26	12
Static	61	92	23	29	15
1985: Probable	55	92	16	23	10
Static	66	92	25	29	14

Source: National Science Foundation

Table A-3.—Estimated percent of men entrants into advanced-degree study in science/engineering fields who attain the doctorate, by field and year of entrance: 1956-67, and Probable and Static projections for entrants of 1980 and 1985

Year of entrance	Percent				
	Physical sciences	Engineering	Mathematical sciences	Life sciences	Social sciences
Fall					
1956	45	20	30	43	31
1957	43	23	33	42	32
1958	43	22	29	42	32
1959	43	22	27	42	34
1960	44	24	25	44	37
1961	43	26	25	46	38
1962	43	26	26	47	38
1963	44	24	27	45	37
1964	42	23	23	41	34
1965	37	20	21	38	32
1966	36	19	19	38	NA
1967	33	NA	18	NA	NA
Projected:					
1980: Probable	19	16	9	28	25
Static	24	21	12	37	34
1985: Probable	14	15	6	24	23
Static	21	22	9	36	35

Source: National Science Foundation

Table A-4.—Estimated percent of women entrants into advanced-degree study in science/engineering fields who attain the doctorate, by field and year of entrance: 1956-67, and Probable and Static projections for entrants of 1980 and 1985

Year of entrance	Percent				
	Physical sciences	Engineering	Mathematical sciences	Life sciences	Social sciences
Fall					
1956	32	NA	NA	27	22
1957	34	12	14	28	23
1958	35	10	15	33	28
1959	32	10	14	34	30
1960	33	9	10	37	31
1961	35	10	9	38	32
1962	31	14	9	33	31
1963	29	17	9	32	30
1964	25	16	8	29	27
1965	25	NA	7	27	NA
1966	22	NA	7	28	NA
1967	19	NA	NA	NA	NA
Projected:					
1980: Probable	14	27	6	25	24
Static	18	27	7	34	33
1985: Probable	12	31	5	24	23
Static	18	31	7	36	35

Source: National Science Foundation

APPENDIX B
Statistical Tables

		Page
B-1.	Baccalaureates, enrollees for advanced degrees, and doctorates as a percentage of specified population age-groups: selected years 1955-74, and Probable and Static projections for 1980 and 1985	26
B-2.	Statistical relationships at successive stages of science/engineering higher education: selected years, 1958-74, with Probable and Static projections for 1980 and 1985	26
B-3.	Science engineering doctorates by major field: total, men, women: 1959-60 through 1973-74 and Probable and Static projections for 1979-80 and 1984-85	27
B-4.	Bachelor's and first-professional degrees, by major field; total, men, women: 1959-60 through 1972-73 and Probable and Static projections for 1979-80 and 1984-85	28
B-5.	Number of college entrants, by sex: fall 1955-74, and Probable and Static projections for fall 1980 and fall 1985	29
B-6.	Enrollment for advanced degrees in science/engineering fields: total, fall 1960-85; men and women, fall 1966-85 and Probable and Static projections for 1980 and 1985	30
B-7.	First-time enrollment for advanced degrees in science/engineering fields: 1960-71 and Probable and Static projections for 1980 and 1985	31
B-8.	First-time enrollment for science/engineering advanced degrees as a percent of baccalaureates in the same science/engineering field in the preceding academic year: selected years, 1960-85	31
B-9.	Science/engineering doctorates as a percent of number of first-time enrollees for an advanced degree in same science/engineering field seven years earlier: selected years 1964-85	31
B-10.	Number of 18-year-olds used as base for development of model projections, by sex: 1945-86	31

Table B-1.—Baccalaureates, enrollees for advanced degrees, and doctorates as a percentage of specified population age-groups: selected years 1955-74, and Probable and Static projections for 1980 and 1985

Year	Baccalaureates in year indicated, as a percentage of population age 22		S/E enrollees for advanced degrees in year indicated, as a percentage of population age 23-29	S/E doctorates in year indicated as a percentage of population age 30
	All baccalaureates[1]	S/E baccalaureates		
1955	13.9	3.9	[2]	0.2
1960	17.8	5.5	0.8	.3
1965	18.1	5.5	1.2	.5
1970	23.6	7.5	1.2	.7
1971	25.3	7.8	1.2	.7
1972	26.9	8.1	1.1	.7
1973	[3]27.2	[3]8.2	[3]1.1	.6
1974	[3]27.2	[3]8.2	NA	.6
Projected:[4]				
1980: Probable	26.1	8.3	.9	.5
Static	27.2	9.0	1.1	.6
1985: Probable	25.2	8.4	.7	.4
Static	28.4	10.1	1.1	.6

[1] Includes baccalaureates in all fields and recipients of first-professional degrees such as L.L.B., M.D., etc.
[2] Data not collected for this year.
[3] Data not available at time projections were made.
[4] See description of projection methodology in appendix A of this report.

Sources: National Center for Education Statistics, HEW, U.S. Bureau of the Census, National Academy of Sciences-National Research Council, and National Science Foundation. U.S. Bureau of the Census, *Current Population Reports* as follows: for 1955, P-25, No. 311; for 1960, P-25, No. 441; for 1965, P-25, No. 385; for 1970-73, P-25, No. 519; for 1974, P-25, No. 529; for 1980 and 1985, P-25, No. 541.

Table B-2.—Statistical relationships at successive stages of science/engineering higher education: selected years, 1958-74, with Probable and Static projections for 1980 and 1985

Year	Number of S/E baccalaureates[1] as percent of average number of college entrants 4 and 5 years earlier	Number of S/E first-time enrollees[1] for advanced degree as percent of number of S/E baccalaureates 1 year earlier	Number of S/E doctorates[1] as percent of number of S/E baccalaureates 8 years earlier	Number of S/E doctorates[1] as percent of number of first-time enrollees for S/E advanced degree 7 years earlier
1958	18	31	3	[2]
1959	18	32	4	[2]
1960	17	34	6	[2]
1963	17	39	10	[2]
1965	17	40	10	30
1968	19	35	12	33
1970	18	30	14	33
1971	18	28	14	31
1972	17	27(est.)	12	28
1973	[3]17	27(est.)	11	27
1974	[3]17	26(est.)	10	25
Projected:				
1980: Probable	18	22	6	23
Static	19	25	8	26
1985: Probable	20	18	5	22
Static	21	25	7	27

[1] Of year indicated.
[2] Data on enrollment for advanced degrees not available for relevant years.
[3] Data not available at time projections were made.

Sources: National Center for Education Statistics, HEW, *Earned Degrees* and *Enrollment for Advanced Degrees* surveys; National Academy of Sciences-National Research Council - earned doctorate data; National Science Foundation—estimates and projections.

Table B-3.—Science/engineering doctorates by major field; total, men, women: 1959-60 through 1973-74 and Probable and Static projections for 1979-80 and 1984-85

Year	Total S/E	Physical sciences	Engineering	Mathematical sciences	Life sciences	Social sciences
			Total			
1959-60	6,056	1,838	786	303	1,647	1,482
1960-61	6,531	1,991	943	344	1,646	1,607
1961-62	7,249	2,122	1,207	396	1,804	1,720
1962-63	8,055	2,380	1,378	490	1,908	1,899
1963-64	9,025	2,455	1,693	596	2,181	2,100
1964-65	10,252	2,829	2,124	688	2,474	2,137
1965-66	11,298	3,045	2,304	801	2,696	2,452
1966-67	12,759	3,462	2,614	870	2,900	2,913
1967-68	14,128	3,593	2,932	983	3,445	3,175
1968-69	15,839	3,859	3,377	1,161	3,779	3,663
1969-70	17,639	4,313	3,681	1,343	4,131	4,171
1970-71	18,466	4,391	3,654	1,327	4,534	4,560
1971-72	18,412	4,103	3,704	1,295	4,478	4,832
1972-73[1]	18,450	3,925	3,500	1,275	4,550	5,200
1973-74[1]	17,800	3,600	3,325	1,250	4,375	5,250
Projected:						
1979-80 Probable	18,100	2,600	2,900	1,000	4,900	6,700
1979-80 Static	21,000	2,900	3,400	1,100	5,700	7,900
1984-85 Probable	16,800	1,700	2,700	700	4,600	7,100
1984-85 Static	24,300	2,400	3,600	1,000	7,000	10,300
			Men			
1959-60	5,674	1,775	783	285	1,521	1,309
1960-61	6,082	1,921	937	327	1,502	1,395
1961-62	6,748	2,035	1,203	372	1,643	1,495
1962-63	7,482	2,285	1,367	454	1,724	1,652
1963-64	8,389	2,342	1,686	567	1,974	1,820
1964-65	9,543	2,702	2,114	628	2,228	1,871
1965-66	10,423	2,914	2,295	744	2,382	2,088
1966-67	11,746	3,300	2,603	810	2,546	2,487
1967-68	12,924	3,405	2,920	931	2,993	2,675
1968-69	14,464	3,653	3,365	1,091	3,295	3,060
1969-70	16,112	4,077	3,657	1,245	3,632	3,501
1970-71	16,666	4,145	3,631	1,231	3,910	3,749
1971-72	16,502	3,830	3,679	1,194	3,831	3,968
1972-73[1]	16,275	3,675	3,450	1,175	3,800	4,175
1973-74[1]	15,450	3,350	3,275	1,125	3,625	4,075
Projected:						
1979-80 Probable	14,900	2,300	2,800	900	4,000	4,900
1979-80 Static	17,300	2,600	3,300	1,000	4,600	5,800
1984-85 Probable	13,000	1,500	2,500	600	3,600	4,800
1984-85 Static	18,900	2,100	3,500	800	5,500	7,000
			Women			
1959-60	381	62	3	18	126	173
1960-61	449	70	6	17	144	212
1961-62	501	87	4	24	161	225
1962-63	573	95	11	36	184	247
1963-64	636	113	7	29	207	280
1964-65	709	127	10	60	246	266
1965-66	875	131	9	57	314	364
1966-67	1,013	162	11	60	354	426
1967-68	1,204	188	12	52	452	500
1968-69	1,375	206	12	70	484	603
1969-70	1,527	236	24	98	499	670
1970-71	1,800	246	23	96	624	811
1971-72	1,910	273	25	101	647	864
1972-73[1]	2,175	250	50	100	750	1,025
1973-74[1]	2,350	250	50	125	750	1,175
Projected:						
1979-80 Probable	3,200	300	100	100	900	1,800
1979-80 Static	3,700	300	100	100	1,100	2,100
1984-85 Probable	3,800	200	200	100	1,000	2,300
1984-85 Static	5,400	300	100	200	1,500	3,300

[1] Estimated by National Science Foundation

Sources: Data through 1971-72: National Center for Education Statistics, HEW, annual *Earned Degrees* reports; 1972-73 and 1973-74: estimated by NSF on basis of National Academy of Sciences-National Research Council Data for these years; projections: National Science Foundation

Table B-4.—Bachelor's and first-professional degrees, by major field; total, men, women: 1959-60 through 1972-73 and Probable and Static projections for 1979-80 and 1984-85

Year	All fields	Total[1] S/E	Physical sciences	Engineering	Mathematical sciences	Life sciences	Social sciences	All other fields[2]
				Total				
1959-60	394,889	120,937	16,057	37,808	11,437	24,141	31,494	273,952
1960-61	401,784	121,660	15,500	35,866	13,127	23,900	33,267	280,124
1961-62	420,485	127,469	15,894	34,735	14,610	25,200	37,030	293,016
1962-63	450,592	135,964	16,276	33,458	16,121	27,801	42,308	314,628
1963-64	502,104	153,361	17,527	35,226	18,677	31,611	50,320	348,743
1964-65	538,930	164,936	17,916	36,795	19,668	34,842	55,715	373,994
1965-66	555,613	173,471	17,186	35,815	20,182	36,864	63,424	382,142
1966-67	594,862	187,849	17,794	36,188	21,530	39,408	72,929	407,013
1967-68	671,591	212,174	19,442	37,614	24,084	43,260	87,774	459,417
1968-69	769,683	224,519	21,591	41,553	28,263	48,713	104,399	525,164
1969-70	833,322	264,122	21,551	44,772	29,109	52,129	116,561	569,200
1970-71	884,386	271,176	21,549	45,387	27,306	51,461	125,473	613,210
1971-72	937,884	281,228	20,887	46,003	27,250	53,484	133,604	656,656
1972-73[3]	980,707	295,391	20,809	46,989	27,528	59,486	140,579	685,316
Projected:								
1979-89 Probable	1,086,000	344,700	18,200	47,300	24,400	59,600	195,200	741,300
1979-80 Static	1,135,000	375,700	19,000	47,400	29,600	68,700	211,000	759,300
1984-85 Probable	1,022,000	342,500	14,000	46,200	19,300	55,200	207,800	679,500
1984-85 Static	1,155,000	408,800	15,900	45,100	28,000	73,600	246,200	746,200
				Men				
1959-60	255,504	101,575	14,041	37,663	8,312	19,650	21,909	153,929
1960-61	255,900	101,065	13,492	35,732	9,483	19,078	23,280	154,835
1961-62	262,015	103,984	13,748	34,610	10,355	19,730	25,541	158,031
1962-63	274,750	108,865	14,038	33,328	11,163	21,627	28,709	165,885
1963-64	299,813	120,888	15,077	35,067	12,682	24,398	33,664	178,925
1964-65	319,670	128,723	15,384	36,656	13,215	26,565	36,903	190,947
1965-66	331,122	133,989	14,853	35,669	13,480	28,400	41,587	197,133
1966-67	355,300	143,847	15,392	36,004	14,196	30,460	47,795	211,453
1967-68	392,830	158,711	16,768	37,403	15,243	33,169	56,128	234,119
1968-69	446,933	181,323	18,639	41,240	17,915	37,405	66,124	265,610
1969-70	486,949	195,244	18,582	44,434	18,593	40,254	73,381	291,705
1970-71	514,220	198,180	18,535	45,022	17,488	39,658	77,477	316,040
1971-72	544,652	203,557	17,739	45,502	17,466	40,790	82,060	341,095
1972-73[3]	568,361	211,552	17,688	46,409	17,543	44,916	84,996	356,809
Projected:								
1979-80 Probable	605,000	227,500	15,700	46,600	15,700	44,200	105,300	377,500
1979-80 Static	632,000	249,000	16,400	46,800	18,300	50,600	116,900	383,000
1984-85 Probable	562,000	216,900	12,300	45,500	12,900	40,500	105,700	345,100
1984-85 Static	636,000	260,100	14,000	44,500	17,200	53,400	131,000	375,900
				Women				
1959-60	139,385	19,362	2,016	145	3,125	4,491	9,585	120,023
1960-61	145,884	20,595	2,008	134	3,644	4,822	9,987	125,289
1961-62	158,470	23,485	2,146	125	4,255	5,470	11,489	134,985
1962-63	175,842	27,099	2,238	130	4,958	6,174	13,599	148,743
1963-64	202,291	32,473	2,450	159	5,995	7,213	16,656	169,818
1964-65	219,260	36,213	2,532	139	6,453	8,277	18,812	183,047
1965-66	224,491	39,482	2,333	146	6,702	8,464	21,837	185,009
1966-67	239,562	44,002	2,402	184	7,334	8,948	25,134	195,550
1967-68	278,761	53,463	2,674	211	8,841	10,091	31,646	225,298
1968-69	322,750	63,196	2,952	313	10,348	11,308	38,275	259,554
1969-70	346,373	68,878	2,969	338	10,516	11,875	43,180	277,495
1970-71	370,166	72,996	3,014	365	9,818	11,803	47,996	297,170
1971-72	393,232	77,671	3,148	501	9,784	12,694	51,544	315,561
1972-73[3]	412,346	83,839	3,121	580	9,985	14,570	55,583	328,507
Projected:								
1979-80 Probable	481,000	117,200	2,500	700	8,700	15,400	89,900	363,800
1979-80 Static	503,000	126,700	2,600	600	11,300	18,100	94,100	376,300
1984-85 Probable	4[illegible]000	125,600	1,700	700	6,400	14,700	102,100	334,400
1984-85 Static	[illegible]000	148,700	1,900	600	10,800	20,200	115,200	370,300

[1] Includes only bachelor's degrees.

[2] Includes bachelor's degrees in nonscience fields and all first-professional degrees (e.g., M.D., L.L.B.)

[3] Data not available at time projections were made.

Sources: Data through 1972-73: National Center for Education Statistics, HEW, annual *Earned Degrees* reports; projections: National Science Foundation.

Table B-5.—Number of college entrants,[1] by sex: fall 1955 to fall 1974, and Probable and Static projections for fall 1980 and fall 1985
[Thousands]

Fall of year	Total	Men	Women
1955	675	418	257
1956	723	446	277
1957	729	445	284
1958	781	469	312
1959	827	491	336
1960	930	543	387
1961	1,026	596	430
1962	1,039	602	437
1963	1,056	609	447
1964	1,234	706	528
1965	1,453	835	618
1966[2]	1,512	865	647
1967[2]	1,577	896	681
1968	1,644	931	713
1969	1,764	993	771
1970	1,796	991	805
1971	1,781	975	806
1972	1,758	937	821
1973[3]	1,775	940	836
1974[3]	1,875	982	893
Projected:			
1980: Probable	1,766	953	813
Static	1,965	1,072	893
1985: Probable	1,448	779	669
Static	1,756	955	801

[1] First-time degree-credit enrollees
[2] Estimated by NSF (NCES did not collect data in this category in these years)
[3] Data not available at time projections were made
Sources: National Center for Education Statistics, HEW, annual Opening Fall Enrollment survey; National Science Foundation

Table B-6.—Enrollment for advanced degrees in science/engineering fields: total, fall 1960-85; men and women, fall 1966-85

Year	Total S/E	Physical sciences	Engineering	Mathematical sciences	Life sciences	Social sciences
			Total			
1960	120,638	25,707	36,636	11,770	19,715	26,810
1961	128,794	26,553	39,367	12,671	21,446	28,757
1962	142,433	28,591	43,850	14,121	23,953	31,918
1963	158,051	30,959	48,917	15,974	26,888	35,313
1964	178,123	34,061	54,318	18,805	30,787	40,152
1965	195,346	36,506	57,516	21,014	34,749	45,561
1966	207,049	37,950	58,338	23,150	37,007	50,604
1967	224,468	40,447	62,633	25,066	39,954	56,368
1968	234,661	40,937	63,662	26,840	41,676	61,546
1969	243,715	39,885	65,048	29,175	44,203	65,404
1970	252,159	40,113	64,788	30,608	46,260	70,390
1971	246,100	38,928	59,321	28,847	47,662	71,342
1972[1]	242,988	36,047	55,847	28,064	49,118	73,912
1973[1]	244,354	35,995	54,567	27,023	50,714	76,055
Projected:						
1980 Probable	237,000	26,500	48,100	22,900	52,500	87,000
1980 Static	287,400	31,100	55,100	28,700	66,800	105,700
1985 Probable	210,600	19,000	45,000	18,100	47,900	80,600
1985 Static	314,800	27,100	57,900	29,100	78,800	121,900
			Men			
1966	180,007	34,769	57,897	19,055	29,693	38,593
1967	193,232	36,824	62,017	20,179	31,802	42,410
1968	199,171	36,988	63,005	21,336	32,520	45,322
1969	204,130	35,645	64,252	22,852	33,966	47,415
1970	208,647	35,441	63,681	23,968	35,398	50,159
1971	201,990	34,398	58,238	22,574	36,584	50,196
1972[1]	196,156	31,673	54,621	21,799	37,345	50,718
1973[1]	194,291	31,344	53,074	20,827	38,077	50,969
Projected:						
1980 Probable	178,100	22,200	45,100	17,900	39,400	53,500
1980 Static	216,300	26,300	52,300	21,300	50,600	65,800
1985 Probable	153,900	15,700	41,200	14,400	35,900	46,700
1985 Static	231,700	22,900	54,600	21,000	59,800	73,400
			Women			
1966	27,042	3,818	441	4,095	7,314	12,011
1967	31,236	3,623	616	4,887	8,152	13,958
1968	35,490	3,949	657	5,504	9,156	16,224
1969	39,585	4,240	796	6,323	10,237	17,989
1970	43,512	4,672	1,107	6,640	10,862	20,231
1971	44,110	4,530	1,083	6,273	11,078	21,146
1972[1]	46,832	4,374	1,226	6,265	11,773	23,194
1973[1]	50,063	4,651	1,493	6,196	12,637	25,086
Projected:						
1980 Probable	58,900	4,300	3,000	5,000	13,100	33,500
1980 Static	71,100	4,800	2,800	7,400	16,200	39,900
1985 Probable	56,700	3,300	3,800	3,700	12,000	33,900
1985 Static	83,100	4,200	3,300	8,100	19,000	48,500

[1] Data not available at time projections were made.

Source: 1960-73 data—National Center for Educational Statistics, annual *Enrollment for Advanced Degrees* report; projections—National Science Foundation. Data were not collected by sex prior to 1966.

Table B-7.—First-time enrollment for advanced degrees in science/engineering fields: 1960-71 and Probable and Static projections for 1980 and 1985

Fall of year	Total S/E	Physical sciences	Engineering	Mathematical sciences	Life sciences	Social sciences
1960	40,500	8,000	12,400	3,800	7,000	9,300
1961	43,300	8,400	12,800	4,500	7,600	10,100
1962	48,200	9,200	14,000	5,100	8,500	11,400
1963	53,400	10,000	15,100	5,600	9,900	12,800
1964	60,300	10,900	16,400	6,500	11,400	15,100
1965	65,300	11,400	17,200	7,200	12,700	16,800
1966	67,400	11,400	17,500	7,700	12,600	18,300
1967	70,600	11,600	18,000	8,000	13,300	19,700
1968	73,900	11,800	18,500	8,500	13,800	21,300
1969	77,300	11,500	19,200	9,500	14,600	22,500
1970	79,200	11,600	19,000	9,500	15,200	23,900
1971	76,400	11,100	16,400	8,800	15,400	24,700
Projected:						
1980: Probable	74,300	7,500	15,400	6,800	16,000	28,600
Static	95,300	9,300	18,300	9,300	21,800	36,600
1985: Probable	61,800	5,000	13,000	5,100	13,900	24,800
Static	100,500	7,800	17,800	9,100	25,100	40,700

Source: 1960-71—estimated by National Science Foundation on basis of magnitude of first-year enrollment for advanced degrees by field (*Enrollment for Advanced Degrees*, annual reports-National Center for Education Statistics) and other parameters for these years (see detailed methodology); 1972-1985—projected by NSF (see detailed methodology). At time projections were made, no National Center for Education Statistics data beyond 1971 were available.

Table B-8.—First-time enrollment for science/engineering advanced degrees as a percent of baccalaureates in the same science/engineering field in the preceding academic year: selected years, 1960-85

Fall of year	Physical science	Engineering	Mathematical science	Life science	Social science
1960	50	33	33	29	30
1965	64	47	37	36	30
1970	54	42	33	29	21
Projected:					
1980: Probable	41	33	28	27	15
Static	49	39	31	32	17
1985: Probable	35	28	26	25	12
Static	49	40	33	34	17

Sources: Baccalaureate data through 1970: National Center for Education Statistics; first-time advanced-degree enrollment estimated by National Science Foundation; projections: National Science Foundation.

Table B-9.—Science/engineering doctorates as a percent of number of first-time enrollees for an advanced degree in same science/engineering field seven years earlier: selected years, 1964-85

Year of doctorate	Physical sciences	Engineering	Mathematical sciences	Life sciences	Social sciences
1963-64	41	18	29	40	28
1964-65	43	20	28	41	26
1965-66	41	20	25	41	29
1966-67	43	21	23	41	31
1967-68	43	23	22	45	31
1968-69	42	24	23	44	32
1969-70	43	24	24	42	33
1970-71	40	22	20	40	30
1971-72	36	22	18	35	29
1972-73	34	20	17	36	28
1973-74	31	18	16	33	27
Projected:					
1980: Probable	25	18	12	30	24
Static	27	20	13	34	28
1985: Probable	20	17	10	29	25
Static	24	21	11	35	31

Sources: Degree data through 1971-72: National Center for Education Statistics, HEW; degree data for 1973 and 1974: National Academy of Sciences-National Research Council and National Science Foundation; estimates of first-time enrollment for advanced degrees and projections: National Science Foundation.

Table B-10.—Numbers of 18-year-olds used as base for development of model projections, by sex: 1945-86

[Thousands]

Year	Men	Women	Year	Men	Women
1945	1,155	1,182	1966	1,795	1,736
1946	1,131	1,161	1967	1,792	1,739
1947	1,137	1,139	1968	1,781	1,725
1948	1,130	1,126	1969	1,830	1,776
1949	1,137	1,111	1970	1,898	1,839
1950	1,090	1,074	1971	1,961	1,902
1951	1,049	1,036	1972	2,011	1,954
1952	1,037	1,021	1973	2,049	1,983
1953	1,089	1,071	1974	2,077	2,006
1954	1,075	1,060	1975	2,159	2,085
1955	1,074	1,068	1976	2,148	2,074
1956	1,132	1,113	1977	2,146	2,079
1957	1,148	1,126	1978	2,121	2,055
1958	1,164	1,143	1979	2,140	2,070
1959	1,228	1,203	1980	2,095	2,026
1960	1,301	1,268	1981	2,068	1,997
1961	1,485	1,454	1982	2,030	1,957
1962	1,402	1,371	1983	1,934	1,875
1963	1,411	1,376	1984	1,837	1,780
1964	1,403	1,370	1985	1,784	1,729
1965	1,899	1,844	1986	1,740	1,681

Sources: U.S. Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P-25, Nos. 311, 385, 411, 441, and 470.

APPENDIX C

Bibliography

Abel, Robert P. "Analysis of the Doctorate Manpower System." Internal study prepared for the National Science Foundation, 1972 (unpublished).

Adams, Walter. "Financial and Non-Financial Factors Affecting Post-High School Plans and Eventuations 1939-1965." *Proceedings of the American Statistical Association*, Social Statistics Section, 1969.

_____ "Some Notes on Reconciliation of College Attendance Rates." Paper written for Office of Education.

_____ "Undergraduate and Postgraduate Enrollments, 1950-1990." Paper written for Office of Education.

American Council on Education. Unpublished tabulations from 1967-71 freshman "National Norms" studies.

National Norms for Entering College Freshmen for years 1961-72. ACE Research Reports. Washington, D.C.: American Council on Education.

Astin, Alexander W. *College Dropouts: A National Profile*. ACE Research Reports 7:1. Washington, D.C.: American Council on Education, Feb. 1972.

_____ *Who Goes Where to College?* Chicago: Science Research Associates, Inc., 1965.

Astin, Alexander W. and Robert J. Panos. *The Educational and Vocational Development of College Students*. Washington, D.C.: American Council on Education, 1969.

Astin, Alexander W., Robert J. Panos, and John A. Creager. *National Norms for Entering College Freshmen—Fall 1966*. ACE Research Reports 2:1. Washington, D.C.: American Council on Education, 1967.

Bayer, Alan E., Jeannie T. Royer, and Richard M. Webb. *Four Years After College Entry*. ACE Research Reports 8:1. Washington, D.C.: American Council on Education, 1973.

Becker, Gary S. *Human Capital: A Theoretical and Empirical Analysis With Special Reference to Education*. New York: National Bureau of Economic Research, 1964.

Berg, Ivar. *Education and Jobs: The Great Training Robbery*. New York: Praeger Publishers, 1970.

Berger, Alan S. *Longitudinal Studies on the Class of 1961: The Graduate Science Students*, Report No. 107. Chicago: Univ. of Chicago, National Opinion Research Center, 1967.

Berls, Robert H. "Higher Education Opportunity and Achievement in the United States." *The Economics and Financing of Higher Education in the United States*. A compendium of papers submitted to the Joint Economic Committee 91st Congress, First Session. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1969.

Bisconti, Ann S. and Helen S. Astin. *Undergraduate and Graduate Study in Scientific Fields*. ACE Research Reports 8:3. Washington, D.C.: American Council on Education, 1973.

Blank, David M. and George J. Stigler. *The Demand and Supply of Scientific Personnel*. New York: National Bureau of Economic Research, 1957.

Bridgman, Donald S. *Alternative Projections of Degree-Credit Enrollments and Earned Degrees in Higher Education, United States, 1966-75*. Washington, D.C.: Commission on Human Resources and Advanced Education, Feb. 1970.

Breneman David W. *An Economic Theory of Ph.D. Production: The Case at Berkeley*. Berkeley, Calif.: Ford Foundation Program for Research in University Administration, 1970.

_____ *The Ph.D. Production Function: The Case at Berkeley*. Berkeley, Calif.: Ford Foundation Program for Research in University Administration, 1970.

Brode, Wallace. "Manpower in Science and Engineering, Based on a Saturation Model." *Science* 173 (July 16, 1971).

_____ "The Scientific and Engineering Manpower Problem of the Future." *Supply, Demand and Utilization of Scientists and Engineers*, special issue of *Manpower Comments*. Washington, D.C.: Scientific Manpower Commission and Engineering Manpower Commission, April 1970.

Bureau of Social Science Research, Inc. *Five Years After the College Degree, Part I—Graduate and Professional Education*. Washington, D.C., June 1965.

The Carnegie Commission on Higher Education. *College Graduate and Jobs, Adjusting to a New Labor Market Situation*. New York: McGraw-Hill, 1973.

_____ *The More Effective Use of Resources, An Imperative for Higher Education*. New York: McGraw-Hill, 1972.

Cartter, Allan M. "Scientific Manpower for 1970-1985." *Science* 172 (April 9, 1971).

_____ "The Economics of Higher Education." *Contemporary Economic Issues* (1969), pp. 145-184.

_____ "The Supply of and Demand for College Teachers." *Journal of Human Resources* 1 (1966).

_____ "Future Faculty Needs and Resources" in Calvin Lee (ed.) *Improving College Teaching*. Washington, D.C.: American Council on Education, 1966.

Chase, Clinton I. *The University Freshman Dropout—Indiana Studies in Prediction Number Six*. Monograph of the Bureau of Educational Studies and Testing. Bloomington, Ind.: Indiana Univ., 1965.

Cheit, Earl. *New Depression in Higher Education*. New York: McGraw-Hill, 1971.

Coffelt, John J. and Dan S. Hobbs. *In and Out of College: A Longitudinal Study of the 1962 Freshman Class in Oklahoma Colleges*. Report 1: The First Year. Oklahoma City: Oklahoma State Regents for Higher Education, Oct. 1964.

Department of Commerce, Bureau of the Census. "Population Estimates." *Current Population Reports*, Series P-25, Nos. 311, 314, 385, 411, 441, 448, 470, 519, 529, and 541. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office.

_____ *Population Characteristics*, Series P-20, Nos. 167, 185, 190, 222, 234, 241, 247, 260, 261, and 278. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office.

_____ *Population Characteristics—Educational Attainment*, Series P-20, Nos. 77, 99, 121, 132, 138, 158, 169, 182, 194, 201, 207, 229, 243, 274, and 279. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office.

_____ *U.S. Census of Population, 1960—U.S. Summary—Detailed Characteristics*, Vol. PC(1)-1D. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1963.

Corazzini, A., D.J. Dugan, and H. Grabowski. "Determinants and Distributional Aspects of Enrollment in U.S. Higher Education." *Journal of Human Resources* II:1 (Winter 1972).

Creager, John A., Alexander W. Astin, Robert F. Boruch, Alan E. Bayer, and David E. Drew. *National Norms for Entering College Freshmen—Fall 1969*. ACE Research Reports 4:7. Washington, D.C.: American Council on Education, 1969.

Creager, John A., Alexander W. Astin, Robert F. Boruch, and Alan E. Bayer. *National Norms for Entering College Freshmen—Fall 1968*. ACE Research Reports 3:1. Washington, D.C.: American Council on Education, 1968.

Davis, James A. *Undergraduate Career Decisions*, Univ. of Chicago, National Opinion Research Center. Chicago: Aldine Publishing Company, 1965.

Davis, James A. *Great Aspirations*, Univ. of Chicago, National Opinion Research Center. Chicago: Aldine Publishing Company, 1964.

_____ *Stipends and Spouses*. Chicago: The Univ. of Chicago Press, 1962.

DeWitt, Laurence B. and A. Dale Tussing. *The Supply and Demand for Graduates of Higher Education: 1970 to 1980*. Syracuse, N.Y.: Syracuse Univ. Research Corp., 1971.

Douglas, John H. "Turning from Science: Shortages Ahead." *Science News* 103 (March 24, 1973).

Eckland, Bruce K. "College Dropouts Who Came Back." *Harvard Educational Review* 34:3 (Summer 1964).

El-Khawas, Elaine H. and Ann S. Bisconti. *Five and Ten Years After College Entry*. ACE Research Reports 9:1. Washington, D.C.: American Council on Education, 1974.

Flanagan, John C., Marion F. Shaycoft, James M. Richards, Jr., and John G. Claudy. *Five Years After High School*. Palo Alto, Calif.: Project TALENT Office, American Institutes for Research and Univ. of Pittsburgh, 1971.

Flanagan, John C. and William W. Cooley. *Project TALENT—One-Year Follow-Up Studies*. Cooperative Research Project No. 2333. Pittsburgh, Pa.: Univ. of Pittsburgh, School of Education, 1966.

Folger, John K., Helen S. Astin, and Alan E. Bayer. *Human Resources and Higher Education*. New York: Russell Sage Foundation, 1970.

Folger, John K. and Charles B. Nam. *Education of the American Population*. A 1960 Census Monograph. Bureau of the Census. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1967.

Ford, Donald H. and Hugh B. Urban. "College Dropouts: Successes or Failures." *Educational Record* (Spring 1965).

Freeman, Richard B. "Manpower Requirements and the Skill Composition of the Work Force: U.S. Experience, 1950-1973." *Scientific and Technical Manpower Projections*, Volume II. Report of the ad hoc Committee on Manpower, National Science Board (NSB 74-287). Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1976.

_____ *The Market for College-Trained Manpower, A Study in the Economics of Career Choice*. Cambridge, Mass.: Harvard Univ. Press, 1971.

Freeman, Richard B. and David W. Breneman. *Forecasting the Ph.D. Labor Market, Pitfalls for Policy*. Washington, D.C.: National Board on Graduate Education, 1974.

Froomkin, Joseph. *Aspirations, Enrollments, and Resources: The Challenge to Higher Education in the 70's*. Office of Education. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1970.

Grigg, Charles M. *Recruitment to Graduate Study*. SREB Research Monograph No. 10. Atlanta, Ga.: Southern Regional Education Board, 1965.

Ginsberg, Eli. "The Outlook for Educated Manpower." *Public Interest* 26 (Winter 1972).

Gropper, George L. and Robert Fitzpatrick. *Who Goes to Graduate School?* Pittsburgh, Pa.: American Institutes for Research, 1959.

Haggstrom, Gus W. "The Growth of Graduate Education in the Post-Sputnik Era." Paper prepared for the Carnegie Commission.

_____ "The Growth of Higher Education in the United States." Paper prepared for the Carnegie Commission.

Hammel, E.A. "Attrition in Graduate School." *Proceedings of the Fifteenth Annual Meeting, Western Association of Graduate Schools*. Tacoma, Wash.: Pacific Lutheran Univ. Press, 1973.

Harmon, Lindsey R. "What Escalates the Doctorates?" Paper for meeting of American Personnel and Guidance Association. Washington, D.C., April 6 1966.

Department of Health, Education, and Welfare, National Center for Education Statistics. *Earned Degrees Conferred*, annual. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office.

_____ *Digest of Educational Statistics*, annual. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office.

_____ *Enrollment for Advanced Degrees*, annual. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office.

_____ *National Longitudinal Study of the High School Class of 1972: Student Questionnaire and Test Results by Sex, High School Program, Ethnic Category, and Father's Education*. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1975.

_____ *Opening Fall Enrollment*, annual. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office.

_____ *Projections of Educational Statistics to 1982-83*. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1974.

_____ *Projections of Educational Statistics to 1983-84* (NCES 75-209). Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1975.

How Many Graduate? New York: City Univ. of New York, Office of the Coordinator of Institutional Research, 1970.

Iffert, Robert E. *Retention and Withdrawal of College Students.* Bull. 1958, No. 1. Department of Health, Education and Welfare, Office of Education. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1957.

Iffert, Robert E. and Betty S. Clarke. *College Applicants Entrants Dropouts.* OE-54034, Bull. 1965, No. 29. Department of Health, Education, and Welfare, Office of Education. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1965.

Jaffe, A.J. and Walter Adams. *Follow-Up of Cross-Section of 1965-66 High School Seniors.* New York: Columbia Univ., Bureau of Applied Social Research, Sept. 1970.

_____ *1971-1972 Progress Report and Findings, Follow-Up of Cross-Section of 1965-66 High School Seniors.* New York: Columbia Univ., Bureau of Applied Research, July 1972.

_____ "Trends in College Enrollment." *College Board Review*, No. 55 (Winter 1964-65).

Jex, Frank B. and Reed M. Merrill. "Student Persistence as Revealed in Longitudinal Graduation Studies." *College and University* (Winter 1967).

Johnston, Denis F. "The U.S. Economy in 1985, Population and Labor Force Projections." *Monthly Labor Review* (Dec. 1973).

Department of Labor, Bureau of Labor Statistics. *The U.S. Economy in 1985.* Bull. 1809. Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1974.

Leslie, Larry L. and Howard F. Miller, Jr. "Higher Education and the Steady State." *ERIC/Higher Education Research Report* No. 4. Washington, D.C.: American Association for Higher Education, 1974.

Lovell, C.C. "Student Flow Models: A Review and Conceptualization." *Preliminary Field Review Edition, Technical Report 25.* Boulder, Colo.: National Center for Higher Education Management Systems at Western Interstate Commission for Higher Education, 1971.

Marsh, John. "The Education and Training of America's Scientists and Engineers: 1962." Report No. 104. Chicago: Univ. of Chicago, National Opinion Research Center, 1963.

Mayhew, Lewis B. *Graduate and Professional Education, 1980.* Carnegie Commission Series in Higher Education. New York: McGraw-Hill, 1970.

Miller, Norman. *One Year After Commencement.* Report No. 93. Chicago: Univ. of Chicago, National Opinion Research Center, June 1963.

Mooney, Joseph. "Attrition Among Ph.D. Candidates: An Analysis of A Cohort of Recent Woodrow Wilson Fellows." *Journal of Human Resources* (Winter 1968).

Morton, J.E. "On Manpower Forecasting." *Methods for the Manpower Analysis*, No. 2. Kalamazoo, Mich.: The W.E. Upjohn Institute for Employment Research, 1968.

National Academy of Sciences-National Research Council. *Doctorate Production in United States Universities, 1920-1962.* Publ. No. 1142. Washington, D.C., 1963.

_____ Unpublished tabulations from Doctorate Record File of doctorate recipients, 1958-1971.

_____ *Doctorate Recipients From United States Universities, 1958-1966.* Publ. No. 1489. Washington, D.C., 1967.

_____ *Doctoral Scientists and Engineers in the United States: A 1973 Profile.* Washington, D.C., March 1974.

_____ *Summary Report of Doctorate Recipients*, annual Washington, D.C.

National Board on Graduate Education. *Graduate Education: Purposes, Problems, and Potential.* Washington, D.C., 1972.

National Opinion Research Center. *The Seniors of 1964.* Report No. 477, unpublished study sponsored by the National Science Foundation, Apr. 1966.

National Science Board. *Scientific and Technical Manpower Projections*, Vol. II. (NSB 74-287). Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1976.

_____ *Science Indicators, 1972* (NSB 73-1). Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1973.

National Science Foundation. *Characteristics of the National Sample of Scientists and Engineers, 1974. Part I. Demographic and Educational* (NSF 75-333). Washington D.C.: Supt. of Documents, U.S. Government Printing Office, 1976.

_____ *Detailed Statistical Tables. Graduate Science Education: Student Support and Postdoctorals, Fall 1973* (NSF 74-318-A). Washington, D.C., 1974.

_____ *Detailed Statistical Tables. Graduate Science Education: Student Support and Postdoctorals, Fall 1974* (NSF 75-322). Washington, D.C., 1975.

National Science Foundation. *Graduate Science Education: Student Support and Postdoctorals, Fall 1972* (NSF 73-315). Washington, D.C.: Supt. of Documents, U.S. Governmentt Printing Office, 1974.

_____ *Projections of Science and Engineering Doctorate Supply and Utilization, 1980 and 1985* (NSF 75-301). Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1975.

_____ *Reviews of Data on Science Resources*, No. 20, "Trends in Graduate Education in Science and Engineering, 1960-70" (NSF 71-15). Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, Nov. 1971.

_____ *Science & Engineering Doctorate Supply & Utilization, 1968-80* (NSF 69-37). Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1969.

_____ *1969 & 1980 Science & Engineering Doctorate Supply & Utilization* (NSF 71-20). Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1971.

_____ *Science Resources Studies Highlights*, "Employment of Life Scientists Up in 1974—Accounts for Nearly All Growth of Scientists and Engineers in Doctorate-Granting Institutions" (NSF 74-315). Washington, D.C., Oct. 1, 1974.

_____ *Science Resources Studies Highlights, "1973 Graduate Science Enrollment Down Another 2 Percent" (NSF 74-308). Washington, D.C., July 30, 1974.*

_____ *Science Resources Studies Highlights*, "Graduate Science Enrollment in 1974 Shows First Increase Since 1969" (NSF 75-328). Washington, D.C., Oct. 22, 1975.

_____ *Science Resources Studies Highlights*, "Graduate Enrollment Up in Biological Sciences, Fall 1974" (NSF 74-321). Washington, D.C., Dec. 31, 1974.

_____ *Science Resources Studies Highlights*, "Graduate Science Enrollment in Fall 1975 is Up Again for Second Straight Year" (NSF 75-335). Washington, D.C., Dec. 31, 1975.

_____ *Science Resources Studies Highlights*, "National Sample of Scientists and Engineers: Participation in National Programs and Changes in Educational Attainment, 1972-74" (NSF 75-317). Washington, D.C., Aug. 5, 1975.

_____ *Scientific Human Resources: Profiles and Issues* (NSF 72-304). Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1972.

_____ *Two Years After the College Degree* (NSF 63-26). Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1963.

Nollen, Stanley D. *The Supply and Demand for College Educated Labor*, unpublished Ph.D. dissertation, Univ. of Chicago, Dec. 1974 (abstract No. ED-100279 in *Research in Education*, May 1975, ERIC Clearinghouse, 1 Dupont Circle, Washington, D.C.).

Orwin, M.D., Paul K. Jones, and Oscar T. Lenning. *Enrollment Projection Models for Institutional Planning*. ACT Research Report No. 48. Iowa City, Iowa: The American College Testing Program, 1972.

Owen, John D. "The Distribution of Educational Resources in Large American Cities." *Journal of Human Resources* II:1 (Winter 1972), pp. 26-59.

Panos, Robert J. and Alexander W. Astin. "Attrition Among College Students." *American Educational Research Journal* V:1 (Jan. 1968).

Panos, Robert J., Alexander W. Astin, and John A Creager. *National Norms for Entering College Freshmen—Fall 1967*. ACE Research Reports 2:7. Washington, D.C.: American Council on Education, 1967.

Pervin, Lawrence. "Counseling the College Dropout." *Journal of College Placement* (Oct.-Nov, 1965).

Powel, John H., Jr. and Robert D. Lamson. *An Annotated Bibliography of Literature Relating to the Costs and Benefits of Graduate Education*. Washington, D.C.: The Council of Graduate Schools, 1972.

_____ *Elements Related to the Determination of Costs and Benefits of Graduate Education*. Washington, D.C.: The Council of Graduate Schools, 1972.

Rosenthal, Neal H. "The U.S. Economy in 1985, Projected Changes in Occupations." *Monthly Labor Review* (Dec. 1973).

Sewall and Shah. "Socioeconomic Status, Intelligence, and the Attainment of Higher Education." *Sociology of Education* (Winter 1967).

Sharp, Laure M. "Graduate Study and Its Relation to Careers: The Experience of a Recent Cohort of College Graduates." *Human Resources* 1:2 (Fall 1966).

_____ *Education and Employment*. Baltimore, Md.: The Johns Hopkins Press, 1970.

Shaycoft, Marion F. *Careers in Science: A Project TALENT Study*. Palo Alto, Calif.: American Institutes for Research, 1975.

Spaeth, Joe L. and Norman Miller, *Trends in the Career Plans and Activities of June 1961 College Graduates*. Chicago: Univ. of Chicago, National Opinion Research Center, March 1965.

Solomon, Lewis C. and Paul J. Taubman (ed.). *Does College Matter. Some Evidence on the Impacts of Higher Education*. New York: Academic Press, 1973.

The Study of Graduate Education at Stanford. Report to the Senate of the Academic Council. Stanford, Calif.: Stanford Univ., 1972.

Stark, Rodney. *Graduate Study at Berkeley: An Assessment of Attrition and Duration*. Berkeley, Calif: Univ. of Calif., Survey Research Center, 1966.

Special Task Force to the Secretary of Health, Education, and Welfare. *Work in America*. Cambridge, Mass.: The MIT Press, 1973.

Student Performance and Attrition at the University of California, Berkeley: A follow-up of the Entering Freshman Classes of Fall 1955 and Fall 1960. Berkeley, Calif.: Univ. of California, Office of Institutional Research, Jan. 1968.

Taubman, Paul and Terrence Wales. *Mental Ability and Higher Educational Attainment in the Twentieth Century*. Berkeley, Calif.: Carnegie Commission on Higher Education, 1972.

Tucker, Allan, David Gottlieb, and John Pease. *Attrition of Graduate Students*, Publ. No. 8. East Lansing, Mich.: Michigan State Univ., Office of Research, 1964.

Warkov, Seymour. *Subsidies for Graduate Students*. Report No. 97. Chicago: Univ. of Chicago, National Opinion Research Center, Mar. 1964.

Warkov, Seymour and John March. *The Education and Training of America's Scientists and Engineers: 1962*. Report No. 104. Chicago: Univ. of Chicago, National Opinion Research Center, Oct. 1965.

Warkov, Seymour, Bruce Frisbie, and Alan S. Berger. *Graduate Student Finances, 1963*. Report No. 103. Chicago: Univ. of Chicago, National Opinion Research Center, Sept. 1965.

Weathersby, George B. *Structural Issues in the Supply and Demand for Scientific Manpower: Implications for National Manpower Policy*. Berkeley, Calif.: Ford Foundation Program for Research in University Administration, May 1972.

Wilson, Logan (ed.). *Universal Higher Education: Costs, Benefits, Options*. Washington, D.C.: American Council on Education, 1972.

Wilson, Kenneth M. *Of Time and the Doctorate*. Report of an inquiry into the duration of doctoral study. SREB Research Monograph No. 9. Atlanta, Ga.: Southern Regional Education Board, 1965.

Withey, Stephen B. *A Degree and What Else? Correlates and Consequences of a College Education*. New York: McGraw-Hill, 1971.

Wolfle, Dael. *America's Resources of Specialized Talent*. The report of the Commission on Human Resources and Advanced Training. New York: Harper & Bros., 1954.

Wolfe, Dael and Charles V. Kidd. "The Future Market for Ph.D.'s." *Science* 173 (Aug. 27, 1971).